PRINCIPLES OF PATTERN AND FOUNDRY PRACTICE

A Textbook in Theory and Practice for the Use of Students in Universities and Technical Institutions

BY

WILLIAM H. RICHARDS

Assistant Professor of Pattern Practice, College of Engineering and Architecture, University of Minnesota

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PREFACE

This book has been prepared with the intention of supplying a text in the study of the fundamental principles of pattern and foundry practice as related to industrial problems.

The text is divided into three parts for convenience in teaching.

The first part deals with the study and layout of shop drawings and blue prints, and the care and use of tools and machinery. The exercises are planned in sequence to illustrate the essential features of pattern construction in bench practice.

The second part describes the method for operating a wood-turning lathe and the parts used in its construction. The turning exercises offer varied uses of wood-turning tools in general and give the student sufficient knowledge of their use in turning more difficult types of patterns as outlined in the lecture problems.

The third part comprises a number of lecture problems from which may be selected topics for discussion. The lectures are planned to give the student a clearer understanding of the more intricate and technical problems involved in the construction and use of patterns, core boxes, follow boards, dry sand moldings, and sweep work, and of the various mechanical devices used in production methods of making castings.

The illustrations in Part I are numbered from 1 to 200, in Part II from 201 to 300, in Part III from 301 to 400.

The course as outlined can be covered during a term of 72 hours, including lectures, and is equivalent to the required amount of work for either 2 or 3 credit hours in technical institutions.

The contents of this book are the result of the author's experience in teaching pattern practice to engineering students and his investigation of engineering problems in the production of castings. To certain friends the author is indebted for their cooperation and help in collecting data and in making many of the drawings contained within this book.

W. H. R.

MINNEAPOLIS, MINN.
September, 1930.

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INTRODUCTION

In studying the subject of pattern practice, the student deals with two different phases of work.

1. He must school himself in the use of the tools and instruments which are used in the construction of patterns. In the average course he has time to acquire sufficient knowledge to enable him to build simple patterns and core boxes of the various general types. The exercises in bench and lathe practice which are presented in this book are intended to accomplish that end.

2. Not less important than a knowledge of the use of tools is an understanding of shop drawings and the basic principles underlying the design of patterns or core boxes and their use in the foundry in making castings.

Careful forethought as to the way in which the pattern can best be used when making the mold and how it can best be constructed to meet the needs of the foundryman in producing a sound and economical casting is essential.

The exercises and lectures are planned to give the student a working knowledge of some of the problems that are found in general pattern and foundry practice in the industrial world. Steam engine cylinder heads, bearings, angle brackets, globe valves, flanged rings, tee pipes, cylinders, flywheel and rope-driven pulleys, gasoline-engine cylinder blocks, pistons, etc., are all discussed and the proper method worked out for making the patterns and core boxes to be used in the production of the castings.

PART I

EXERCISES IN BENCH PRACTICE

PRINCIPLES OF PATTERN AND FOUNDRY PRACTICE

INTRODUCTION TO PART I

Bench practice in woodwork is well expressed through the art of pattern making, since it involves a knowledge of woodworking tools and the technique of their use in carving, shaping, and fitting together such pieces as may be required in the construction of a pattern.

A good assortment of tools is essential to doing good work. Tools such as planes, chisels, gouges, knives, spokeshaves, and saws are called "edge tools," on account of their cutting qualities. Other tools, such as try-squares, shrinkage rules, dividers, calipers, gages, screw drivers, bit braces, boring bits, nail sets, and hammers, complete the assortment generally used in the construction of patterns.

Tools.—A knowledge of the sharpening and the care of tools is no less important, since much of the success in using them depends upon the condition in which they are kept.

Work Benches.—Benches on which the pattern is constructed likewise are important. The bench should be smooth, clean, and level, and equipped with a satisfactory vise, bench stop, and tool drawers.

Sharpening Edge Tools.—Edge tools in general, such as planes, chisels, and gouges, are sharpened by grinding the tool to the desired shape and angle. They are then honed to a fine cutting edge on an oil stone. The average bevel for grinding a plane iron or chisel is at an angle of about 25 deg. from its face.

Grinding Machines.—The grinding is best done on a power oil-stone tool grinder or water-cooled grindstone. When ground on a dry emery wheel, the tool should be dipped frequently into water which prevents it from burning.

Process.—The process of bench practice consists in the art of using tools in their proper relation to the object being constructed.

Position.—The stance taken at the bench for the operation of tools, together with the plan of holding the material securely on the bench and in the vise, is important.

Holding.—Proper holding and control of tool operation in executing detail of construction.

Drawings.—The knowledge of reading and making shop drawings and the reproduction of such information into the desired object, according to the prescribed specifications.

Application.—The application of bench practice is outlined in a progressive set of exercises designed to give a varied use of tools, as well as to impart the fundamental principles of pattern making as related to industrial practice.

Presentation.—In presenting the course, a practical demonstration and explanation of the use and care of tools is essential.

Procedure.—The student should be informed as to the kind of material to be used and the amount of time allowed for each project. He will then begin on the assigned task under the direction of the instructor.

Exercise 1

CAP-IRON PATTERN

Instructions for the Use of Tools in Construction of Cap-iron Pattern.—In making this pattern, the intention is to illustrate the use of a balanced core, which necessitates making the length of the core print equal to that of the unsupported portion of the core when placed in the mold.

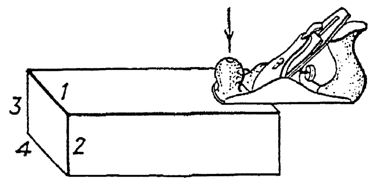


FIG. 1.

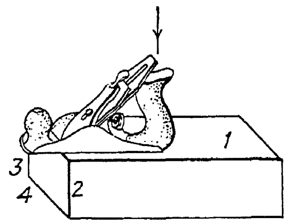


FIG. 2.

First select a piece of stock suitable to be worked down to the dimensions shown in the diagram (Fig. 9). The rough surface of one side is first planed off with the jack plane, after which the jointer plane is used in finishing this same side to a true surface. Mark this side 1.

Side 2 is next made by planing in the same manner, using the try-square to test surface 2 with surface 1.

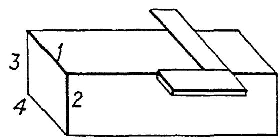


FIG. 3.

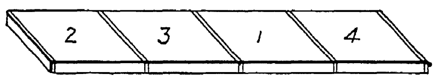


FIG. 4.

The marking gage should next be set to $1\frac{1}{4}$ in. and a line gaged along surface 1 using surface 2 as a guide. Side 3 is then made in the same manner as side 2.

The fourth side is made by gaging from side 1, a line on surfaces 2 and 3 which forms side 4, and is finished in the same manner as in the preceding surfaces.

Next place the blade of the try-square on surface 1 and $\frac{1}{16}$ in. from the end of the piece, holding the square as in Fig. 3. With a

knife, mark a line on surface 1, and repeat on sides 2, 3, and 4, which will determine the finishing lines for this end of the piece. Next measure off the length 5¼ in. and repeat, marking in the same manner as on the opposite end. Any surplus on the ends should then be cut away with a saw to within 1/16 in. of the finishing line.

Next hold the piece in a vertical position in the vise and, with a wide paring chisel, chamfer or bevel off all four edges of the ends down to the finishing lines (see Fig. 8 for tool position). The ends should then be chiseled to a true and square surface by using a wide paring chisel, holding it at a suitable angle to produce a shearing cut. This is best done by holding the chisel

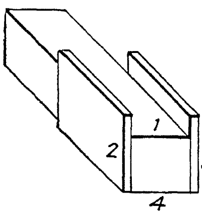


FIG. 5.

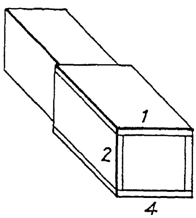


FIG. 6.

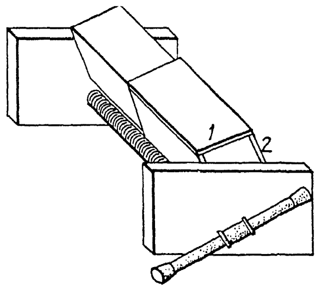


FIG. 7.

at an angle of about 45 deg. to the side from which the operator is working.

Next select a piece of stock long enough to make all four pieces, as in Fig. 4, using the same method of planing, chiseling, etc., as outlined in the preceding paragraphs.

Attach two of the pieces to the core-print block on sides 2 and 3, keeping the lower edge flush with side 4, using four ¾-in. brads and glue to fasten the pieces to the core-print block. Remove the projecting surplus stock of sides 2 and 3, using chisel and plane, after which sides 1 and 4 are attached in the same manner (see Fig. 6).

The pattern should then be held in the vise as in Fig. 7 and, with a block plane, all four edges should be rounded to a ⅛-in. radius. Next the ends are rounded down in the same manner, a chisel or block plane being used for this operation (see Fig. 8). Next the pattern should be carefully sandpapered. On that part of the pattern next to the core print, best results are obtained when rounding off the corners by using a small piece of sandpaper

held in the fingers. The making of the pattern is now complete. It should have a perfectly smooth surface before it is varnished.

All patterns and core boxes should be given at least two coats of shellac. The first coat applied should be quite thin; this will allow the shellac to penetrate well into the wood and seal the grain.

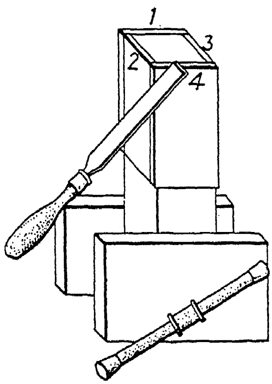
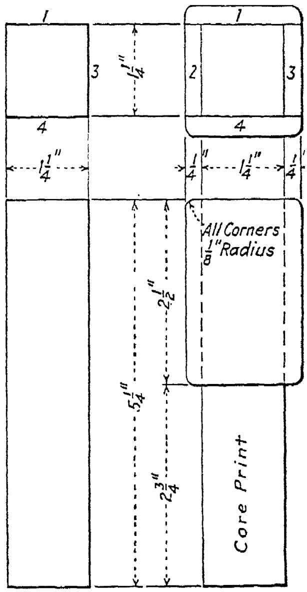


FIG. 8.



G. 9.

When the first coat has dried, the surface should be sandpapered very lightly, then dusted off, thus being made ready for the final coat.

After the first coat has been applied, fill in all nail holes or other blemishes with wax. If fillets are required, they should be made at this time.

Any small particles of dust or wax remaining on the surface to be shellacked should be removed with a piece of clean cheesecloth slightly moistened with turpentine. This will leave the surface perfectly smooth and clean for the application of the following coats.

Exercise 2

CORE BOX FOR CAP-IRON PATTERN

Instructions for Making Core Box for Cap-iron Pattern.—A core box is an auxiliary part of a pattern used to form a sand core, which represents the shape of the internal opening in a casting. In this exercise, a frame core box is selected in order to give some further practice in the use of tools and to supply

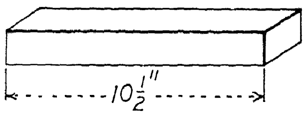


FIG. 10.

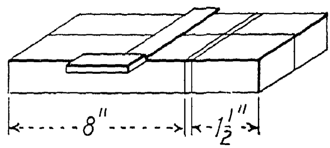


FIG. 11.

a core box which is used with the cap-iron pattern (Exercise 1) in illustrating the use of a balanced core when making the casting. To make this pattern proceed as follows:

Select two pieces of stock 7/8 by 1 3/8 by 10 1/2 in. Plane each piece, as in Exercise 1, to 5/8 by 1 1/4 by 10 1/2 in. Next square up the ends as in Exercise 1, using a wide chisel.

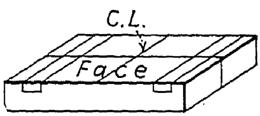


FIG. 12.

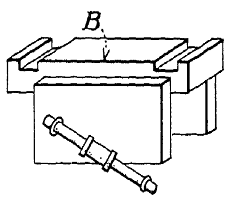


FIG. 13.

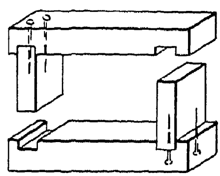


FIG. 14.

Place the two pieces together as shown in Fig. 11, and with square and knife mark off 8 in. from one end and 1 1/2 in. from the opposite end as shown by the two lines in Fig. 11. Next place one piece in a vise with the 1 1/4 in. surface up as indicated in Fig. 13 and, with backsaw held in position on the upper inside edge *B*, as indicated in Fig. 13, cut off the 1 1/2 in. piece. Next cut to size the 8-in. piece. Remove, and repeat the same operation on the other piece. Each of these four pieces

should then be finished to size by chiseling the rough ends as before.

Next line up the two 8-in. pieces with the 1¼-in. surfaces exposed and mark a center line (C. L.) across the faces as shown in Fig. 12. With dividers set at 2½ in., mark off 2½ in. on each side of the center line. Reset dividers to 3⅛ in. and repeat the layout as before. With square and knife, mark off lines parallel with the center line as shown in Fig. 12. Next set the marking gage to ⅛ in. and mark parallel lines on both edges using the face

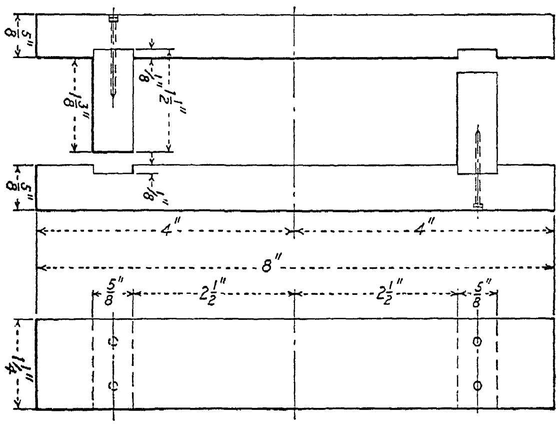


FIG. 15.

of the piece as a guide for the gage. Project lines on both edges of each piece to intersect with the gage lines.

Place each piece in a vise, as shown in Fig. 13, and cut away the stock between the lines, using a backsaw and a ½-in. chisel. Finish the vertical edges with a wide chisel in order to form a perfect shoulder and slot to receive the end pieces.

Next assemble one side and one end of each piece using glue and two 1¼-in. brads (see Fig. 14). Submit your work to the instructor for a final check-up before shellacking.

When both parts of the core box have been completed, they should be fitted together to form the shape of the desired core. Each half-side of the core box should fit into the opposite groove, but do not force the fit. Each part should be carefully sandpapered before varnishing.

Exercise 3

ANGLE-BRACKET PATTERN

Instructions for Making an Angle Bracket.—This exercise is used to give additional practice in making and combining the different parts used in the construction of patterns. In this case, the core prints are made as separate parts and are later

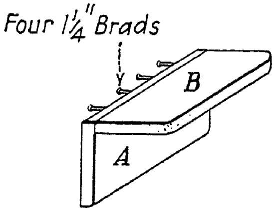


FIG. 16.

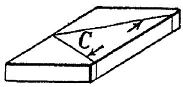


FIG. 17.

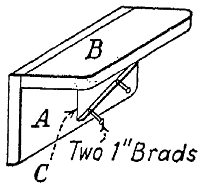


FIG. 18.

attached to the pattern. This type of core print is used for supporting the core when the opening in the casting comes below the parting line of the mold. Angle-bracket castings of this type are useful in bridge and building construction for reinforcing and holding purposes. They are used on those parts of the

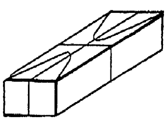


FIG. 19.

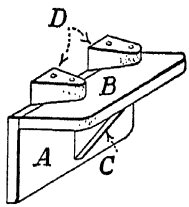


FIG. 20.

structure that come together at the same angle as that of the bracket (usually a right angle).

When cored openings are required on both sides of the bracket casting, the openings in the vertical section are made by the use of dry-sand cores, while a choice of dry- or green-sand cores may be used in the horizontal section, as indicated in Fig. 21.

This pattern is made as follows:

Select stock suitable for making this pattern, as shown by the dimensions in the diagram (Fig. 21), using proper tools to reduce the rough stock to the required size as in exercise 2. Next assemble *A* and *B* to form a right angle, using four 1-in. brads and glue to fasten them together. Next place the pattern in a vise that holds it by the ends. This places the pattern in a horizontal position, a convenient one for rounding down the two inside edges of the pattern.

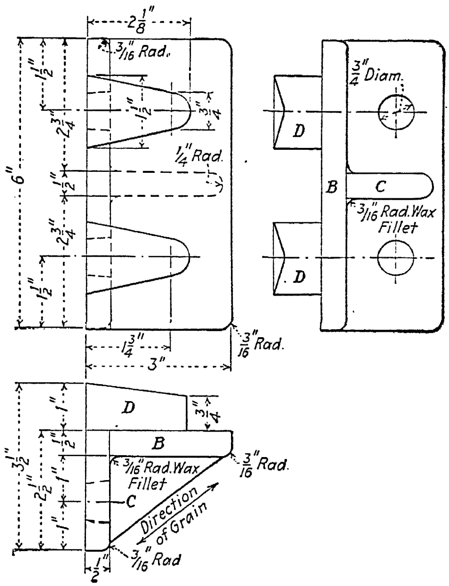


Fig. 21.

Next make the web, rounding the edge before fastening it to the pattern and keeping the direction of the grain as per diagram (Fig. 21).

To fasten the web as indicated in Fig. 18, it is placed centrally and nailed in from the rounded edge, with two 1-in. brads.

The core prints are then made by planing a piece of stock down to 1½ in. in width by 1 in. in thickness. The length of the rough stock should not be less than 4½ in. After the planing has been done, the ends are squared up as in Exercise 1. The marking gage should then be set at ¾ in. and a center line drawn on both sides and both ends (Fig. 19). Next set the gage

at 1¾ in., and from each end gage lines (on both sides) to intersect the center line. This will give centers for describing ¾-in. circles. Next draw tangent lines to the circles from the corners of the piece. The piece should then be sawed in two and carefully chiseled and planed to the lines, which will form the sides of the core print. The curved end should next be chiseled to size, after which the taper is formed by marking the rounded end to ¾ in. in thickness. The operation is completed by chiseling off the surplus stock to shape the prints as shown in the diagram, part *D*. Hold the print in the vise with the rounded edge toward the inside jaw of the vise.

The location of the core prints is then determined. They are then fastened in place by using two 1¼-in. brads, nailing them on so that the ends of the core prints will be flush with the face of *A* and with the taper as indicated (see diagram, Fig. 21, part *D*). This is best done after the pattern, including the varnishing, has been completed. The core prints should also be varnished before they are attached permanently to the pattern. By using this method, a much better piece of work is obtained.

Exercise 4

CORE BOX FOR ANGLE-BRACKET PATTERN

Instructions for Making Core Box for Angle Bracket.—This type of core box is used with the angle-bracket pattern (Exercise 3) when making the mold for the casting. The core formed in this box is for making the bolt hole, which comes below the parting line of the mold. The opening in the core box must conform

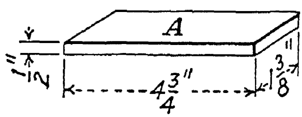


FIG. 22.

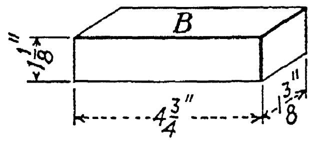


FIG. 23.

to the shape of the core print on the pattern as well as to the shape of the opening to be made in the casting. The core box is made as follows:

Select two pieces of stock about 9/16 by 1½ by 4¾ in. and two others about 1¼ by 1½ by 4¾ in. Plane all four pieces, first planing one surface and one edge of each piece, next setting the marking gage at 1⅜ in. to give the same width on all four pieces,

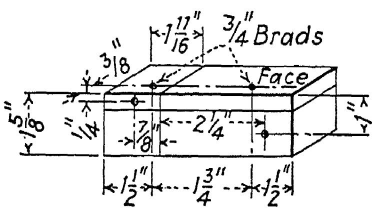


FIG. 24.

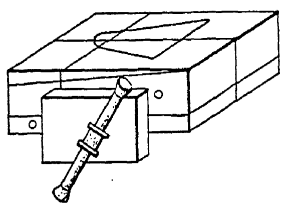


FIG. 25.

after which the thickness is made in similar manner (see diagram, Fig. 26, parts *A* and *B*). Leave a rough length of 4¾ in.

Next assemble one of the ½-in. pieces and one of the 1⅛-in. pieces, using two ¾-in. brads, placed 1½ in. from each end of the rough stock and ⅜ in. from the outside edge. Repeat for the other two pieces. Next measure 1 11/16 in. from one end of the piece and square a line on all four surfaces, as in Fig. 24. Next

locate the position of the dowel pins on the edge of the piece by measuring $\frac{7}{8}$ in. to the left of the center line just drawn, and $2\frac{1}{4}$ in. to the right, placing centers of holes $\frac{1}{4}$ in. and 1 in., respectively from the face of the $\frac{1}{2}$-in. piece as shown in the diagram. The two pieces should next be placed together on the table of the boring machine (or in a vise for hand drilling). Keeping the two pieces properly in line with each other, with a $\frac{1}{4}$-in. bit, bore the dowel pin holes according to layout. Next make two dowel pins $1\frac{3}{4}$ in. long, pointing one end as shown in the diagram (Fig. 26). Next insert the dowel pins as shown.

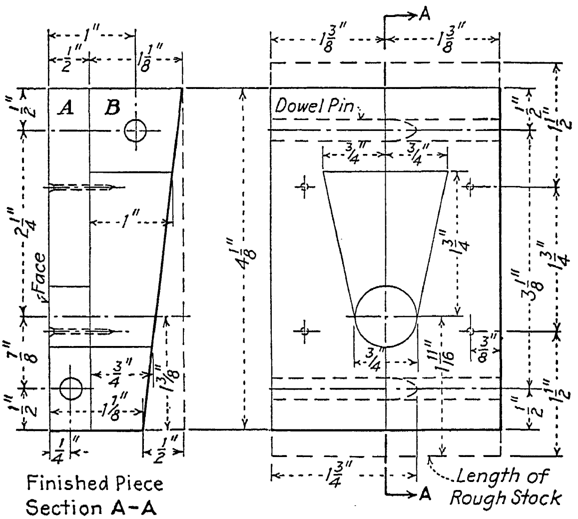


FIG. 26.

Next hold the pieces in the vise and proceed to lay out the lines that determine the shape of the core (see top view on diagram, Fig. 26). On the opposite side describe a $\frac{3}{4}$-in. circle on the same center line. Next remove part *A* from part *B*, and complete the same layout on the inside surfaces of *A* and *B*. Next saw, chisel, and gouge away the stock lying within the lines of layout, working from both surfaces towards the center of each piece, after which these parts should be carefully sanded. Next assemble parts *A* and *B*, using the original brad centers and two additional brads to make a secure fastening. Next mark off, with knife and square, the length of the core box as per diagram (Fig. 26). Saw away the surplus stock on

the ends and plane down to the required size. The taper on the open side of the box should next be made by gaging a line across the end of the box 1⅛ in. from the face (see Fig. 26). Mark lines on the outside edges to determine the taper, and remove the surplus stock by sawing and planing down to finished size, holding the assembled box in a vise, as in Fig. 25.

It is important to have the dowel pins made as shown in the diagram (Fig. 26). The pins are used for assembling the two halves of the core box together, and must be made to have a free working fit, as well as to hold the two parts of the core box properly together while the core is being rammed.

Exercise 5

COUPLING CORE BOX

Instructions for Making Coupling Core Box.—When cores are of a symmetrical shape, such as a cylinder, they are usually made in

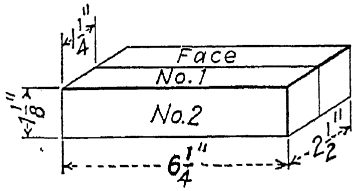


FIG. 27.

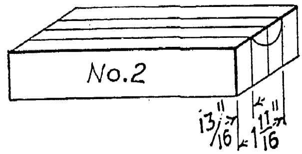


FIG. 28.

a half core box and when baked are pasted together to form the complete core. The core box shown in this exercise illustrates this type of box and is made as follows:

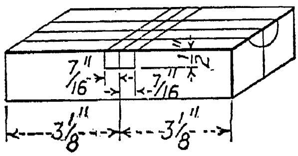


FIG. 29.

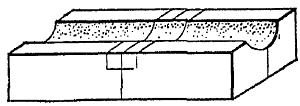


FIG. 30.

Select a piece of suitable stock and finish down to 1⅛ by 2½ by 6¼ in., chiseling or planing to length in the same manner as in Exercise 1, using knife and square in marking the ends.

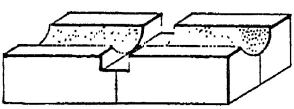


FIG. 31.

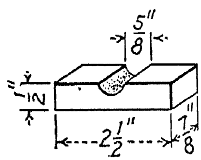


FIG. 32.

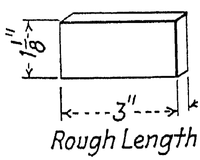


FIG. 33.

Set the marking gage at 1¼ in. and gage a center line on the face side and both ends, using side 2 as a guide for the gage.

Next set the dividers at 7⁄16 in. and describe a semicircle on each end, using the face side of the piece as a center point for the

dividers. The gage should then be reset to $^{13}/_{16}$ in., and a line marked on the face of the piece, side 2 being used as a guide for the gage. Reset the gage to $1^{11}/_{16}$ in. and repeat the operation.

On the face side of the piece, lay off the lines representing the location of the cross-groove (see Fig. 29), using dividers, square, knife, and gage. The gage is set at $\frac{1}{2}$ in. to mark the depth of the groove.

With backsaw, cut down to $\frac{1}{2}$-in. line, leaving sufficient stock on the sides of the groove, which is later finished with a paring chisel and a $\frac{1}{2}$-in. chisel for the bottom surface. Before making the groove for the inlay piece (Fig. 30), gouge out the stock lying within the parallel lines and semicircles on ends. Then the above-mentioned inlay groove should be completed.

The core box should now appear as in Fig. 31, and at this point should be sanded along the semicircular groove but not in the inlay groove.

A piece should next be made as indicated in Fig. 32, with a $\frac{5}{8}$ in. wide semicircular opening. Insert the piece in the groove, using care in centering with the $\frac{7}{8}$-in. groove. Fasten with glue and two 1-in. brads (see diagram, Fig. 34).

Next make the end pieces from a piece of stock about $\frac{5}{8}$ by $1\frac{1}{4}$ by 6 in., planing down to correct thickness and width. This piece is then cut in two parts (see Fig. 33), and each piece is attached to the ends of the box with two 1-in. brads and finished flush on all surfaces. The box should then be inspected by the instructor, and, if satisfactory, it should then be given the first coat of black shellac. When dry, the core box should be lightly sanded, and a $\frac{1}{16}$-in. wax fillet should be formed with a round-end waxing iron (see diagram, Fig. 34). A second coat of black shellac should then be applied and left to dry.

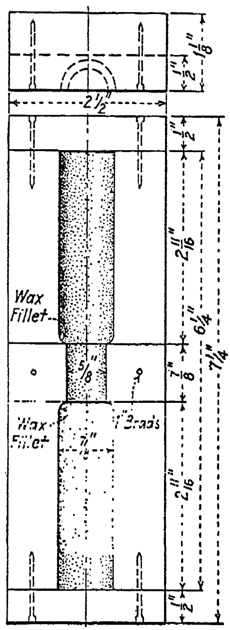


FIG. 34.

Exercise 6

CONNECTING-LINK PATTERN

Instructions for Making Connecting-link Pattern.—This type of pattern illustrates the advantage of the composite plan of construction over one which might be used if the pattern were made from solid material. Details of construction are as follows:

For making a connecting-link pattern, select a suitable piece of wood and plane down to ½ by 2½ in., leaving the length not less

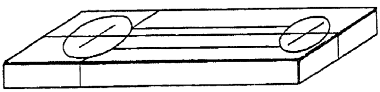


FIG. 35.

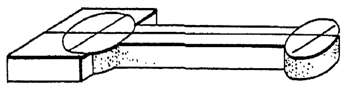


FIG. 36.

than 6¾ in. One end should then be planed or chiseled to a square surface, which will form the end of the core print. Next gage a center line on both sides of the piece, setting the marking gage at 1¼ in. Next locate center of the large boss (shown in Fig. 36) by gaging a line to intersect the center line 1¼ in. from the end of the core print. With dividers set at ¾ in., describe a

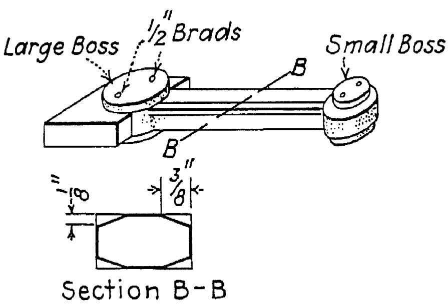


FIG. 37.

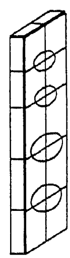


FIG. 38.

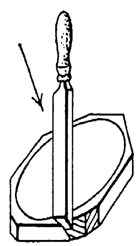


FIG. 39.

circle on both sides of the piece (on core print end). This determines the location of the boss. Next set the dividers at 4½ in. and point off the center of the small boss (see Fig. 40). Reset the dividers to 1 1/16 in. and describe a circle on both sides of the piece. This determines the shape of the end of the pattern. With the marking gage set at ¾ in., gage a line on both sides of

the piece parallel with the center line, using side 2 as a guide for the gage (see Fig. 35). Reset the gage at 1¾ in. and repeat the operation for the second parallel line.

The piece should now be formed into shape by cutting away, on the band saw, the surplus stock lying outside of the dotted line as shown in the diagram (Fig. 40), leaving 1/16 in. for chiseling. The piece should then be chiseled to the finish line as in Fig. 36.

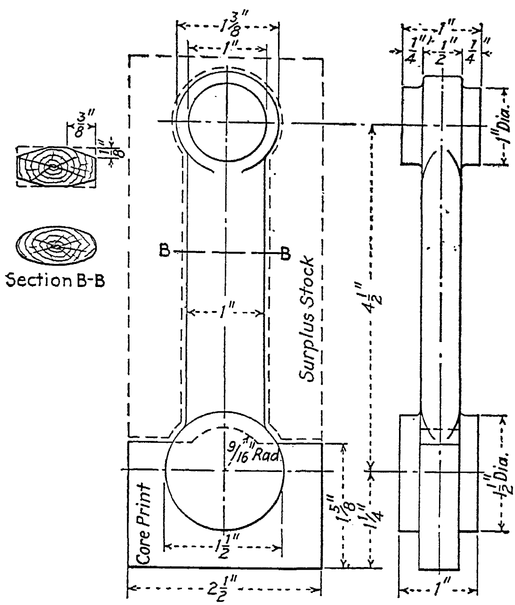


FIG. 40.

Next draw parallel lines on the face and the edge of the piece as shown in Fig. 37, keeping these lines as per section *BB*.

The bosses are next made by planing a piece of stock to a thickness of ¼ in. and not less than 1¾ in. in width and 6 in. in length. This piece should be sufficient to make all four bosses. Project a center line on both sides of the piece, and lay out the bosses on each side according to Fig. 38.

Saw out the bosses on the band saw, leaving about 1/16 in. for chiseling, which should be done by placing the boss on a chiseling block on top of the bench, and directing the chisel obliquely (see arrow, Fig. 39) through the grain of wood. This will produce a shearing cut. The boss should be carefully

chiseled from both sides to give a satisfactorily shaped edge, ofter which the edge should be lightly sanded. The bosses are next attached to the pattern in their respective places (as per circles already described) by fastening them with two ½-in. brads, allowing the points of the brads to penetrate into the body of the pattern. After this a light film of glue should be put on each boss and the brads driven down flush in their original centers. The grain of the bosses should be parallel to that of the pattern. The piece should then be held in a vise, the ends of the pattern being placed between the jaws of the vise. This method of holding the pattern will enable you to adjust it in a convenient position for chiseling the edges of the arm, as shown in section *BB*.

The arm should be completed by chiseling away the projecting edges to form the proper shape as shown in section *BB* in the diagram (Fig. 40). Sandpaper and shellac, then form a ⅛-in. wax fillet around these bosses where they come in contact with the arm.

Exercise 7

CONNECTING-LINK CORE BOX

Instructions for Making Connecting-link Core Box.—The connecting-link core box is made to open on its opposite corners for convenience in removing the core from the box. When making the core, the box is clamped together and rammed on the plate which is used when baking the core.

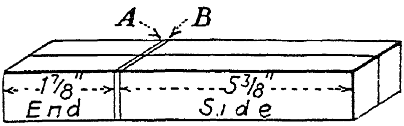


FIG. 41.

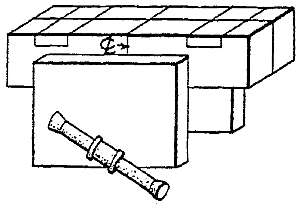


FIG. 42.

This core box is made from two pieces of stock ⅝ by 1 by 8 in. long, and is planed down to the dimensions shown in the diagram (Fig. 47). Each piece should be squared and chiseled on one end. Place the pieces together, as in Fig. 41, holding them in a vise as in Fig. 42, keeping the squared ends in line with each other. Next measure off 1⅞ in. from the squared end, using try-square and knife. On the opposite end of each piece mark

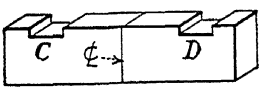


FIG. 43.

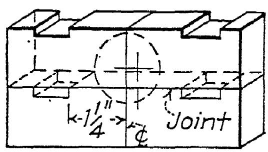


FIG. 44.

a line about $\frac{1}{16}$ in. from the rough end. From this line measure 5⅜ in., and from this point mark a line which will give the length of the sides of the core box. Remove the two pieces from the vise, and with square and knife project these lines on the remaining three surfaces of each piece. The surplus stock lying between

lines *A* and *B* should next be cut away with a backsaw, leaving only enough for chiseling to a square surface.

After the ends of all four pieces have been properly squared and chiseled, the two sides should be placed together with the

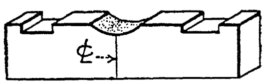


FIG. 45.

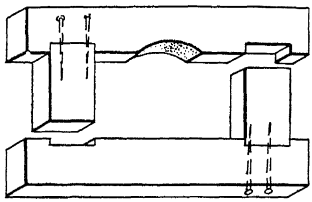


FIG. 46.

thickness of each piece turned upward. They should be held in the vise as in Fig. 42. Next find the center of the length of pieces, and, with dividers set at 1¼ in., mark inside shoulders

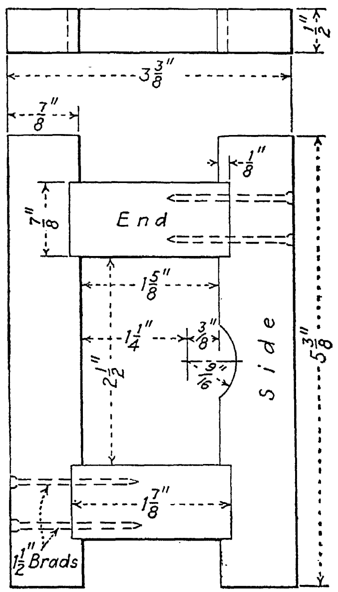


FIG. 47.

C and *D*. Reset the dividers at 2⅛ in., and from the same center line mark the outside shoulder lines.

Remove from the vise, and, with the marking gage set at ⅛ in., gage lines on both faces of each piece to form the depth of the

shoulders. Mark the lines with knife and square on each face, to complete the layout of the shoulders. The stock should be removed between the shoulder lines, using saw and chisel. When completed it will appear as in Fig. 43.

Project center line on both faces of one of the side pieces and, using this piece as a center point for the dividers, describe on the other piece a circle of $\frac{9}{16}$-in. radius, keeping the center point $\frac{3}{8}$ in. from the joint of the two pieces (see Fig. 44). With a suitable gouge form the concave shape, as in Fig. 45. Next the ends and sides are fastened together by gluing and nailing the diagonal corners, as shown in Fig. 46. Both pieces should now be sandpapered and finished with two coats of black shellac.

Exercise 8

RELIEF-VALVE CORE BOX

Instructions for Making Relief-valve Core Box.—The relief-valve core box is a good illustration of the use of a balance core and can be understood by referring to the relief-valve pattern diagram (Fig. 237, lathe work). The purpose and method of

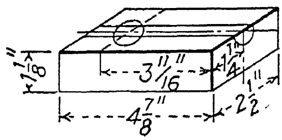


FIG. 48.

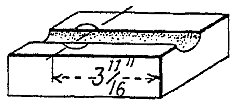


FIG. 49.

placing such a core in the mold, which is held in place by the extended length of the core print *E*, will be readily seen.

To make the core box, plane the stock down to the required size as shown in the diagram (Fig. 56), after which the marking

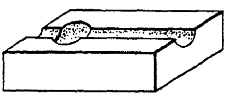


FIG. 50.

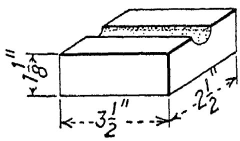


FIG. 51.

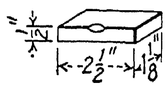


FIG. 52.

gage should be set to 1¼ in. and a center line drawn on the face of each piece and parallel with the sides of the stock. Project this center line on both ends of each piece. With dividers, describe a ⅝-in. semicircle on the ends of each piece. Next set


FIG. 53.

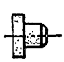


FIG. 54.

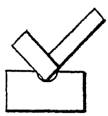


FIG. 55.

the marking gage and draw parallel lines to connect the semicircles. The globe, or bowl, of the core box should next be laid out. This is done by describing a 1¼-in. circle on the face side of the core box 3 11/16 in. from the core-print end (see Figs. 48 and 49).

Next remove the stock lying within these lines with suitable gouges by first using a ½-in. gouge to make the semicircular groove, and by then using a spoon gouge to make the bowl. The opening should be carefully tested with a square, and, if the box has been properly made, the outside corner of the square should describe a perfect circle (see Fig. 55), which shows the square touching on all three points).

The box should next be sandpapered with a ½-in. round dowel pin used as a sandpaper block. The globe cavity can be

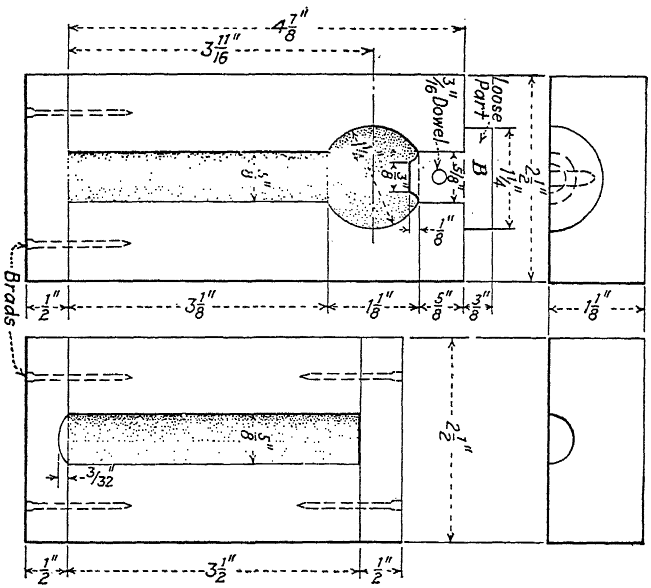


Fig. 56.

better smoothed by using a small piece of sandpaper, holding it between the forefinger and thumb, care being taken not to allow the sandpaper to wipe off the sharp edges of the box.

The loose part *B*, which forms the seat of the valve, should next be turned up, and, inasmuch as a half core box is used, the surplus of this piece should be cut away with a chisel and the remaining portion carefully fitted to coincide with the face side of the box.

The ends of the boxes should next be made and attached by using 1¼-in. brads, keeping all face surfaces flush. When complete, the core boxes should be given two coats of shellac.

BRASS-BEARING PATTERN

Instructions for Making Brass-bearing Pattern.—This type of pattern illustrates the principle of "draft." When making the pattern, care should be taken to have all parts properly tapered before assembling.

In making this pattern, first select suitable stock to be finished to the dimensions shown in the diagram (Fig. 61). Plane the

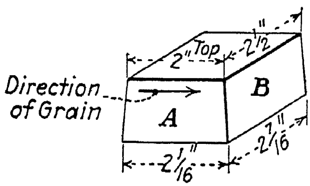


FIG. 57.

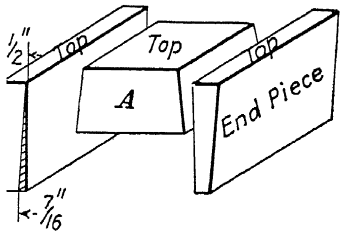


FIG. 58.

stock down to the required size, taking care to have the grain of the wood running in the direction of the arrow on the 2-in. edge of the piece (see Fig. 57). When completed, the sides of the block marked *A* should be 2 in. long at the top and $2\frac{1}{16}$ in. long at the bottom, and the sides marked *B* should be $2\frac{1}{2}$ in. at the top

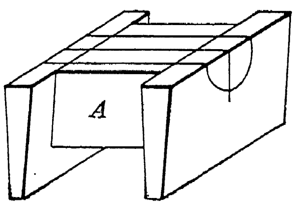


FIG. 59.

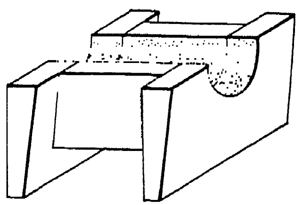


FIG. 60.

and $2\frac{7}{16}$ in. at the bottom. This difference in size is called the "draft of a pattern," and is made to facilitate the drawing of the pattern from the sand without injury to the mold.

Plane the two end pieces to the required sizes as shown in the diagram (Fig. 61), finishing them to $\frac{1}{2}$ in. in thickness at the top and $\frac{7}{16}$ in. in thickness at the bottom, and 2 in. in width

by 3½ in. in length. The end pieces are drafted to correspond with the draft on the block.

With the glue and 1-in. brads fasten the ends to the block, placing the brads as shown in the diagram (Fig. 61), keeping the top edges of the end pieces flush with the top side of the block.

Locate and describe the center line, shown in the diagram (Fig. 61), and project it on the ends of the piece. Describe a 1½-in.

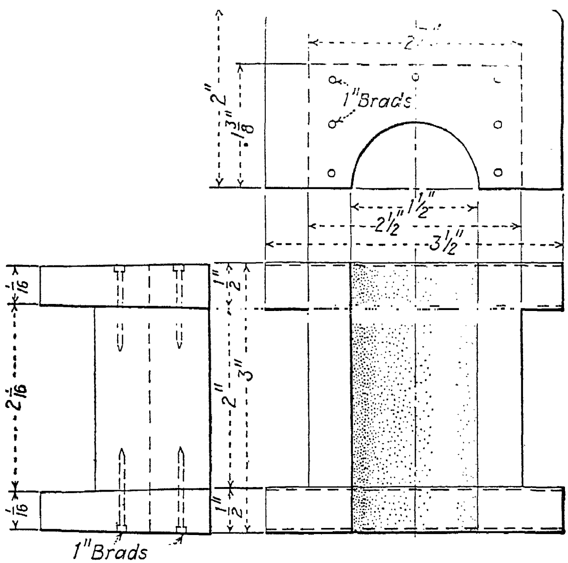


FIG. 61.

semicircle on each end of each piece, and join these semicircles with lines drawn parallel to the center line across the top side of the block.

With band saw and suitable gouge, remove the stock lying between these lines, forming the concave surface as shown in Fig. 60.

As the work progresses, the accuracy of the curve should be tested with a try-square or any other 90-deg. angle. The pattern should next be sandpapered, by using a 1⁵⁄₁₆-in cylinder as a block when sanding the hollowed-out portion. Two coats of orange shellac should then be applied.

Exercise 10

OIL-CUP CORE BOX

Instructions for Making Oil-cup Core Box.—In this exercise the making of a half core box for an oil cup is presented. When used in practice, it requires two impressions of the half core, which are pasted together to form the complete core.

To make the core box, first plane the piece of stock to $1\frac{1}{8}$ in. in thickness by $2\frac{1}{2}$ in. in width by 4 in. in length (see diagram, Fig. 66).

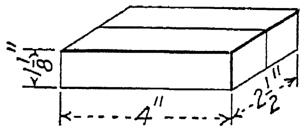


FIG. 62.

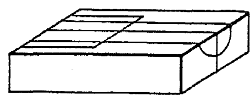


FIG. 63.

Next lay out the opening to be made by setting the marking gage at $1\frac{1}{4}$ in., and gage a center line along the face side and on both ends of the piece (see Fig. 62).

Next set the dividers at $\frac{1}{2}$ in. and describe a 1-in. semicircle on each end of the block, keeping the point of the divider on the joint made by the face side of the block and a temporary piece used when describing the circle. Reset the divider at $\frac{5}{8}$ in.

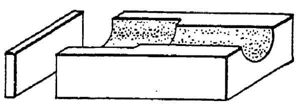


FIG. 64.

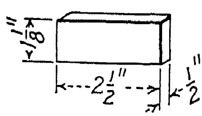


FIG. 65.

and describe a $1\frac{1}{4}$ in. semicircle on one end of the block, using the same center as when describing the 1-in. semicircle (see diagram, Fig. 66, end view).

From this end, measure back $1\frac{3}{4}$ in. and with square and pencil draw a line across the face side of the block (see Fig. 63). This will determine the distance along the surface for the $1\frac{1}{4}$-in. semicircle that is to be cut into the block.

Next set the gage to correspond to the 1-in. semicircle described on the ends of the block, and gage two parallel lines along the full length of the piece. Reset the gage to the 1¼-in. semicircle and gage the line back as far as the 1¾-in. cross-line. This will determine the depth of the opening in the oil-cup casting.

Next the block should be clamped in the vice, holding the ends of the block between the jaws of the vise. This will prevent splitting of the block while the opening is being made. With a suitable paring gouge first cut away the stock between the two 1-in. parallel lines. This will give a 1-in. semicircular opening, the full length of the piece.

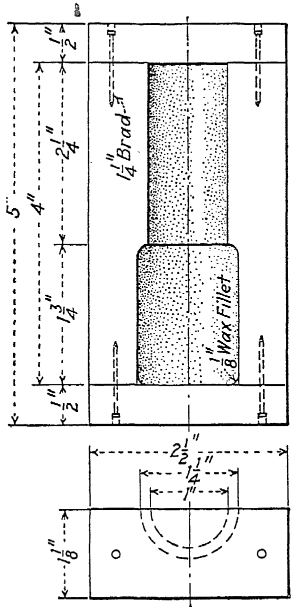


FIG. 66.

The 1¼-in. semicircle is next made by first cutting into the block with a ⅛-in. short bend gouge which forms the fillet at the 1¾-in. cross-line (see diagram, Fig. 66).

The opening is then completed in the same manner as in the 1-in. semicircle, care being taken to blend the fillet and the sides of the opening together.

The core box should next be sandpapered to give a smooth and even surface, within the space representing the shape of the core, and at the same time the sharp edges of the opening, which forms the joint of the core, should be preserved.

The two end pieces are next made from a piece of suitable stock that will finish to ½ by 1⅛ by 2½ in. These are fastened to the ends of the box as shown in the diagram (Fig. 66).

After the core box has been given a first coat of shellac, a wax fillet is formed at the end of the box, which gives a rounded corner in the bottom of the oil-cup casting. The core box should be lightly sanded, and a second coat of shellac should be applied to protect the wax fillet and preserve the surface of the core box.

PART II

EXERCISES IN LATHE PRACTICE

INTRODUCTION TO PART II

In operating a wood-turning lathe it is quite important that the operator should be well informed of the working parts of the machine.

Wood-turning lathes in general are made up of the following parts: the bed, headstock, tailstock, tool rest, face plates, spur and cup centers, driving dogs, etc.

The lathe bed forms the base on which the headstock and tailstock are mounted on, and provides a working surface on which the tool rest may be adjusted to the requirements of the piece being turned up in the lathe. The bed is usually supported on legs of a height convenient for the operator.

The headstock is that part of the lathe which supplies the power and is mounted on the bed. When a belt-driven head is used, a step pulley and a corresponding countershaft are supplied to make possible the various speeds needed in wood turning.

Should the headstock be of the motor-head type, the cone pulley is not necessary, on account of the variable speed control which governs the speed of the motor. In both types of headstock, a hollow spindle is used which is made to hold the driving center, as well as to accommodate the use of the face plate. The spindle projects about 2 in. beyond the outside of the bearing on each end of the pulley and has a thread to fit that of the face plate.

The tailstock holds the dead or cup center and can be adjusted to any distance within the length of the bed. After the adjustment has been made, the tailstock should be securely clamped to the bed to prevent shifting when the lathe is set in motion. The cup center in the tailstock differs from that which is used in the headstock in as much as the center remains in a fixed position about which the piece being turned revolves.

The tool rest can be adjusted to any position which best suits the support of the hand tools. When turning between centers the top of the tool rest should not be placed higher than the axis of the lathe centers. When used in this position, a proper bearing

for the tool is obtained, as well as a satisfactory cutting contact with the piece being turned.

Face-plate.—A metal face plate about 6 in. in diameter is supplied with the lathe and has an internal thread to correspond to the thread on the headstock spindle. When this plate is not sufficiently large to accommodate the work, it is customary to increase its diameter by attaching a wooden disk, of a suitable size, to that of the piece under consideration for turning.

The wooden plate should be turned on the edge and face to give a true working surface, after which the piece to be turned is attached by means of wood screws.

Lathe Centers.—The spur center is used in the headstock of the lathe and is so designed that it will penetrate the end of the wood when placed in position for turning. This makes a driving contact.

The cup or dead center is used in the tailstock of the lathe and forms a bearing for the opposite end of the piece to be turned.

Speed Adjustment.—The speed of the lathe is governed by the belt arrangement between the countershaft and the cone pulley on the headstock end of the lathe or by the variable speed control on a motor-driven head. When turning small parts, best results are obtained at a speed of about 2,500 r.p.m.

Wood turning is classified under two groups, namely, turning between centers, and "face-plate work," the latter being used when flat parts such as flanges, built-up rings, disks, etc., are to be made. When cylinders, columns, and such pieces are to be made, they should be turned up between centers.

Exercise 1

CYLINDER PATTERN

Instructions for Making Cylinder Pattern.—To demonstrate the use of the lathe and to serve as a first exercise in wood turning, a small cylinder pattern has been selected, which will give the student an opportunity to use the more simple kinds of turning tools and measuring instruments.

The pattern is made from a piece of pine stock or similar soft wood about 2 in. by 2 in. by 8½ in. in length. It is made by first finding the center on each end of the piece, as in Fig. 208, and then placing it between the spur center of the headstock and the dead center of the tailstock, after which the tailstock adjustment should be securely fastened to prevent the piece from working loose while in motion.

Care should be taken to have the piece of stock working freely when the power is applied; otherwise the friction of the dead center will cause the bearing to burn. This can be overcome by placing a lubricant on the tailstock center before starting the lathe in motion.

The first operation is done with a 1-in. turning gouge, which is used to rough off the surplus stock in preparation for the finishing of the piece.

The gouge should be held firmly in the hand and at an angle suitable to give a shearing cut, as in Fig. 202.

The skew chisel is next used in turning down the piece to the finished size. When used as in Fig. 203, it will produce a shearing cut, which insures a smooth and even surface.

When turning between centers with any turning tool, best results are obtained by distributing a downward pressure of the tool between the tool rest and the surface being turned, at the same time holding the tool at an angle which will produce a shearing cut, as in Fig. 203. This method will give a better contact between the cutting edge of the tool and the surface of the stock, and will help to keep the tool from chattering.

After the piece has been turned to the proper diameter, as shown in the diagram (Fig. 212), the ends of the cylinder and core

prints are formed. This is done by first measuring off 1 in. on the cylinder from the tailstock end, from which the first end and the core print are formed as shown in the diagram (Fig. 212;

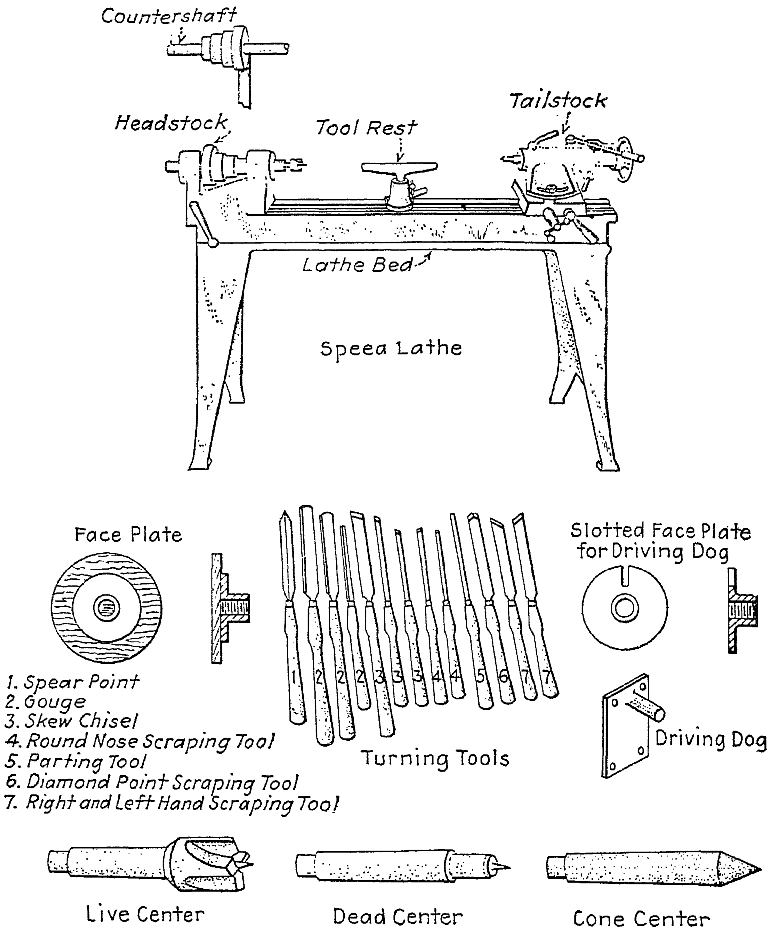


FIG. 201.

see also Fig. 209 for layout). This operation is best done with the point of a ½-in. skew chisel held as shown in Fig. 205.

When cutting the vertical end of the cylinder, care must be taken to hold the cutting edge of the tool at an angle of 90 deg. to the line of the lathe centers and at the same time to keep the heel of the tool clear from the outside corner of the cylinder. By

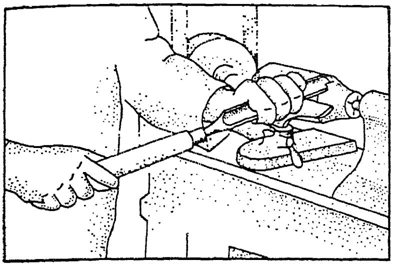


Fig. 202.

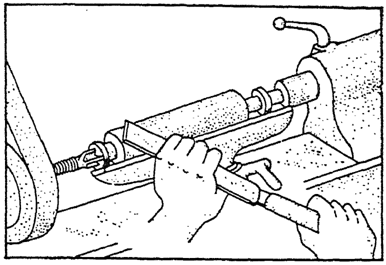


Fig. 203.

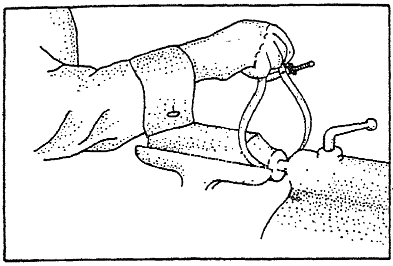


Fig. 204.

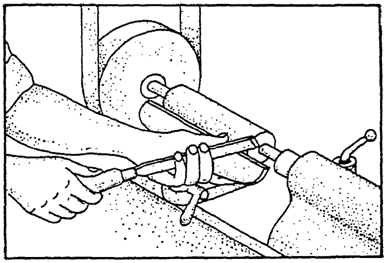


Fig. 205.

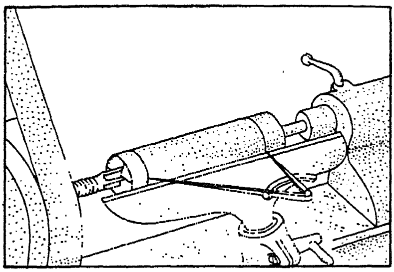


Fig. 206.

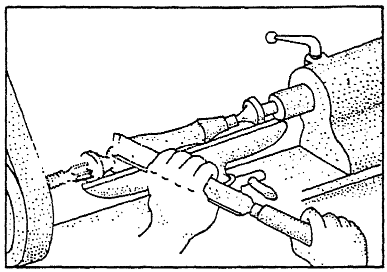


Fig. 207.

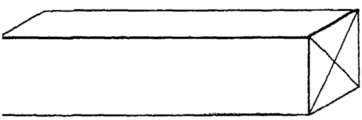


Fig. 208.

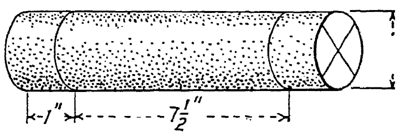


Fig. 209.

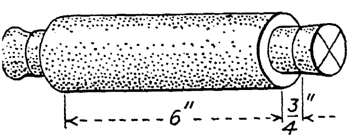


Fig. 210.

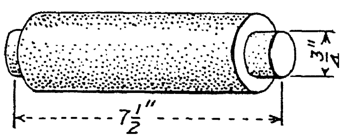


Fig. 211.

holding the tool in this manner, you will avoid a kick-back of the tool.

The ends of the cylinder are formed in this manner, and the stock is reduced horizontally to the required diameter of the core print. In this way a suitable clearance for the cutting edge of the tool is obtained, and the stock is turned down to the desired size.

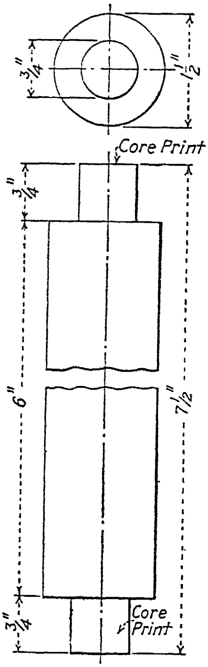


FIG. 212.

The length of the cylinder should now be measured off from the finished end, and the core print on the opposite end should be completed in the same manner as was the first (see Fig. 210).

When using the dividers for setting out measurements on the cylinder while it is revolving, it is best to hold the instrument so that the points will come in contact with the surface of the cylinder a little below the center of the axis of the lathe, as in Fig. 206.

The core prints should be made to their proper length, as in Fig. 212, by first setting the dividers at 3/4 in. and scribing their length from each end of the cylinder. The point of the skew chisel is used for cutting and forming the ends of the core prints. In using the skew chisel it is best not to cut more than 1/8 in. into the stock. This will prevent the piece from breaking off before it has been fiinished.

Next the cylinder should be carefully sandpapered and the surplus ends removed with backsaw and pearing chisel, after which the pattern is ready for varnishing, as in Fig. 211.

Exercise 2

HOSE-COUPLING PATTERN

Instructions for Making Hose-coupling Pattern.—This hose-coupling pattern and core box (shown in bench practice, Exercise 5) are used when making the mold for the coupling casting. The coupling is used for joining two lengths of hose by means of threaded ends.

The pattern is made as follows:

Select a piece of stock that will turn down to 1⅞ in. in diameter by 6¼ in. in length, as in Fig. 214.

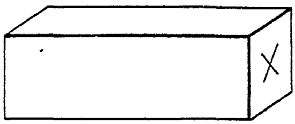


Fig. 213.

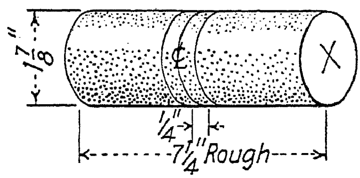


Fig. 214.

Measure off half the length of the cylinder and strike a center line (see Fig. 214). Set the dividers at ¼ in. and space from the center line the width of the hexagonal. With small turning gouge and skew chisel reduce the stock on each side of the hexagon to 1⅜ in., forming the fillet with a ½-in. turning gouge held in the

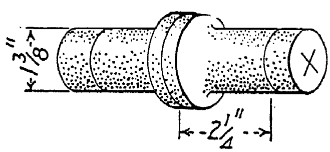


Fig. 215.

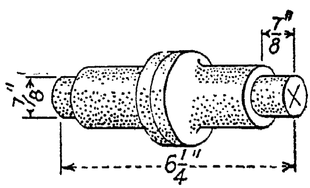


Fig. 216.

same position as that in the illustration showing the use of lathe tools (Fig. 202). The gouge, when held in this position, will avoid tearing the stock and will give a smooth surface.

Next measure off 2¼ in. on each side of the center line. At these lines, cut down with the point of the skew chisel (see illustration, Fig. 205), and turn the core prints of the pattern

to 7/8 in. in diameter and 7/8 in. in length. With the heel of the skew chisel round off the ends of the pattern next to the core prints (see diagram, Fig. 219).

The piece should next be sandpapered, after which the hexagonal part of the pattern should be spaced off with the

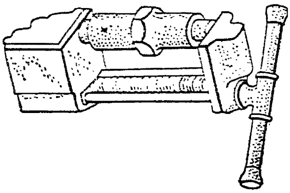


FIG. 217.

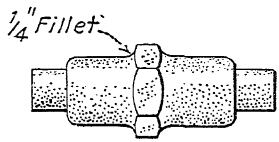


FIG. 218.

dividers, the top of the tool rest being used as a guide in marking the parallel lines of the hexagonal nut (see illustration, Fig. 206 for position of tool rest).

When this part of the work has been completed, the pattern is removed from the lathe and clamped in the vise as shown

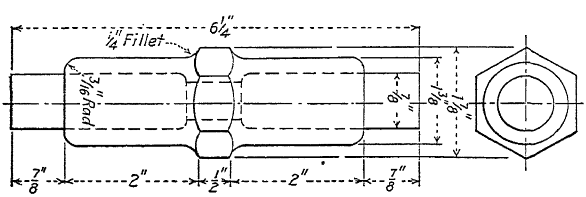


FIG. 219.

in Fig. 217 with a wide paring chisel, cut off the surplus stock in forming the hexagonal nut of the pattern.

Remove the pattern from the vise, and with saw and chisel finish off the ends of the core prints.

Exercise 3

PACKING-GLAND PATTERN

Instructions for Making Packing-gland Pattern.—A packing gland is used on that part of a valve, pump, or piston connection where a tight compression joint is required. The pattern is of the one-part type and is molded on end. The core is held in a vertical position by means of the top and bottom core prints.

To make the pattern proceed as follows:

Select a piece of stock that will turn down to $1\frac{5}{8}$ in. in diameter by 5 in. in length.

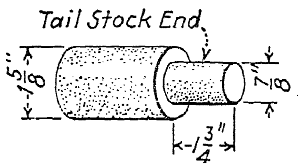


FIG. 220.

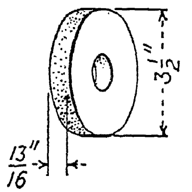


FIG. 221.

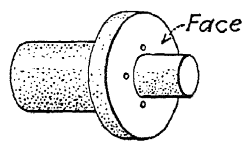


FIG. 222.

Measure off $1\frac{3}{4}$ in. from the tailstock end of the piece, and with point of skew chisel form a shoulder on this end, turning the stock down to $\frac{7}{8}$ in. in diameter (Fig. 220).

Next cut out, on the band saw, a disk $3\frac{1}{2}$ in. in diameter by $\frac{13}{16}$ in. in thickness. Bore a $\frac{7}{8}$-in. hole through the center of the disk, as in Fig. 221.

Place the disk on the shank, and face off the side next to the tailstock using the diamond-point scraping tool. Next reverse the disk on the shank bringing the faced surface tight against the shoulder of the piece (Fig. 222), using glue and four $1\frac{1}{2}$ in. No. 16 wire brads to fasten it.

Turn the flange down to $3\frac{1}{4}$ in. in diameter by $\frac{3}{4}$ in. in thickness, using round-nosed and diamond-point scraping tools (see Fig. 222). From the face of the flange measure off a thickness of $\frac{1}{2}$ in., and with round-nosed scraping tool form a $\frac{1}{4}$-in. fillet between the flange and the cylinder, finishing the flat surface of the flange with the diamond-point scraping tool (see Fig. 223).

Next set the calipers at $2\frac{3}{8}$ in. and from the face side of the flange measure off on the cylinder the total length of the pattern. At this point mark and cut in with the point of the skew chisel in

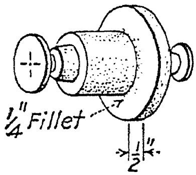


FIG. 223.

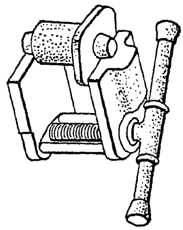
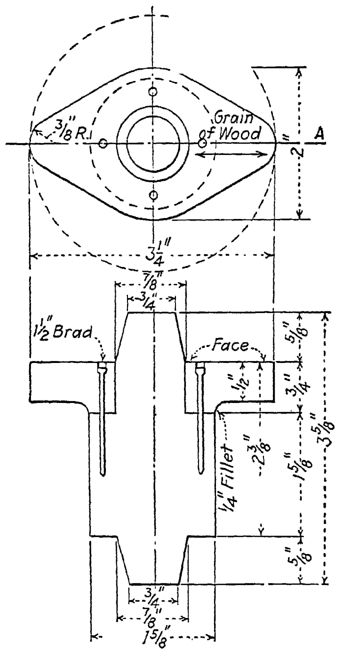


FIG. 224.

the same manner as that used in making the shoulder for the flange. The core prints should next be turned down to proper



Section A-A

FIG. 225.

shape and ..., first ... nearest the tailstock. the ... has h... be sanded.

Next strike a 2-in. circle on the face side of flange, using calipers and pencil. The pattern should then be removed from the lathe and placed in the vise with the face of the flange turned upward. In this position, the shape of the flange can be conveniently laid out as in the diagram (Fig. 225), care being taken to have the grain of the wood running with the length of the flange.

Use a center square for finding the center line of the flange as at *AA* in the diagram (Fig. 225).

With dividers set at $\frac{3}{8}$ in., use center line *AA* for centers of circle. Mark off the ends of the flange by drawing tangent lines to the 2-in. circle. The pattern should next be clamped in the vise, as in Fig. 224. With a paring chisel, remove the surplus stock, finishing down to the working lines of the flange.

After removing the pattern from the vise, smooth the edges of the flange with sandpaper. The surplus stock on the end of each core print (Fig. 223) should now be removed with back-saw and chisel, leaving the core prints perfectly smooth on the ends. The tool work on the pattern is now finished, and the pattern is ready for varnish.

Exercise 4

RELIEF-VALVE PATTERN

Instructions for Making Relief-valve Pattern.—Valves of this type are generally used on stationary boilers. The pattern for

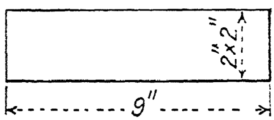


FIG. 226.

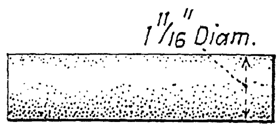


FIG. 227.

the body of the valve is represented in this exercise and suggests the use of a balanced core when molded.

This exercise will require the use of all the turning tools and instruments used in the preceding exercises. It is made as follows: Turn a cylinder to finish $1^{11}/_{16}$ in. in diameter by 9 in. in length from a piece of 2-in. stock (Fig. 226). Next measure off $4^3/_{16}$ in. from the head-stock end of the lathe and strike a center line on the cylinder (see Fig. 228). From this line proceed to form the globe part of the pattern by setting the dividers at $^9/_{16}$ in. From the center line space off the width of globe (see part *A*, diagram, Fig. 231).

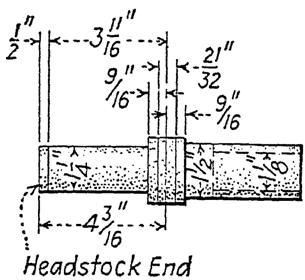


FIG. 228.

Next turn down the cylinder to $1\frac{1}{2}$ in. in diameter, to form the diameter for making the hexagonal part *B*, using the point

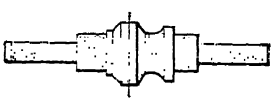


FIG. 229.

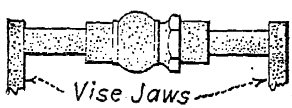


FIG. 230.

of skew chisel at the intersection of the globe and hexagonal diameters (see diagram, Fig. 231). Repeat the same operation on the opposite end, reducing the stock to $1\frac{1}{4}$ in. in diameter.

Set the dividers at 1½ in. and measure off from center line to the back of the hexagon. From this line space off ⅜ in., which forms the width of hexagon (see diagram, Fig. 231). Next form the globe and at the same time form the concave neck and shoulders (see part *C*, diagram, Fig. 231), using a ½-in. turning gouge and a ½-in. skew chisel. Complete the operation on each end of the

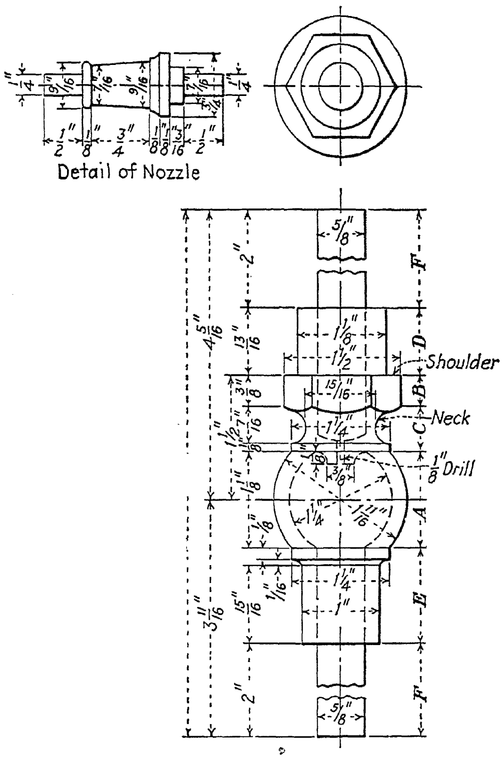


Fig. 231.

piece, first forming the shoulder and tail part *D*. Reduce tail part *D* to 1⅛ in. in diameter (see Fig. 228). Repeat the operation on the opposite end of the piece forming part *E*. Next form the core prints marked *F* by reducing the two ends to by 2 in. in length.

When this part of the pattern has been completed, the piece should be carefully sandpapered. Then the hexagonal part of the

pattern marked *B* should be spaced off with the dividers, the top of tool rest being used as a guide for marking the parallel lines.

Remove the pattern from the lathe and with backsaw and chisel finish off the ends of the core prints.

The piece should next be clamped in the vise. Holding it as in Fig. 230 and with a paring chisel, form the hexagon.

Exercise 5

OIL-CUP PATTERN

Instructions for Making Oil-cup Patterns.—A pattern for an oil-cup casting, which might be used on the connecting rod of a steam engine, is selected for this exercise. It is made up in the form of a divided or split pattern, commonly called a two-part pattern.

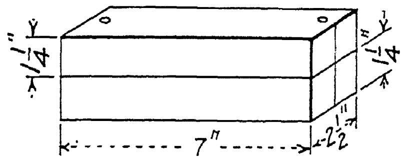


Fig. 232.

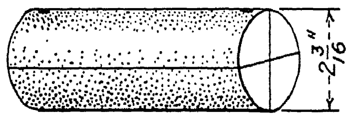


Fig. 233.

In making the pattern, first select two pieces of stock 1¼ in. thick by 2½ in. wide by 7 in. long. Plane the wide surface of each piece to a true surface. Place trued surfaces together, and fasten through each end, with one 2-in., No. 12 wood screw, keeping the screws ½ in. from the ends of the piece. This is best done by drilling with a 3/16-in. drill for the screws and then countersinking for the screw heads (see Fig. 232).

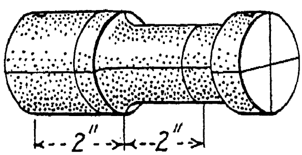


Fig. 234.

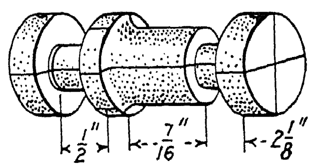


Fig. 235.

Next center up the piece for turning, using the joint of the two pieces as a center line, on which the centers of the lathe must come. Rough off the stock with turning gouge, and then with skew chisel, turning the cylinder to 2 3/16 in. in diameter as in Fig. 233.

From the headstock end of the cylinder measure off 2 in., and with small gouge form the fillet between the hexagonal and the

cylindrical part of the pattern, and at the same time reduce the stock to form the 1½-in. diameter of the pattern, using the skew chisel in combination with the gouge (see Fig. 234).

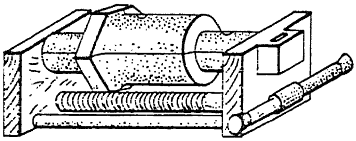


FIG. 236.

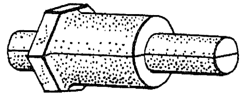


FIG. 237.

Next the end of the pattern is made by measuring off 2 in. from the line of the fillet (see Fig. 234). With the point of the skew chisel mark the end of the pattern.

The core print is next made by reducing the stock to 1 in. in diameter by 2⅛ in. in length. While this part of the work pro-

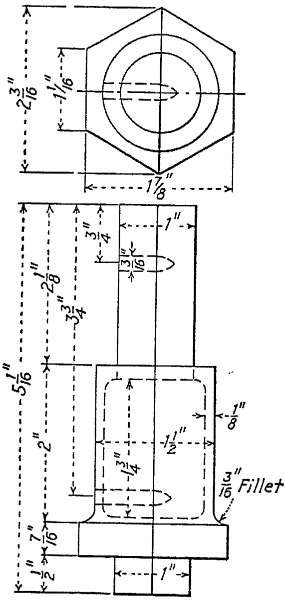


FIG. 238.

gresses, the end of the cup is also formed with the skew chisel. Next measure back 7/16 in. for the hexagonal, from the fillet line, and with skew chisel and gouge form the 1-in. shank and shoulder, in the same manner as the core print. Clearance between the

surplus stock and the ends of the pattern must be given in order to make a finished end.

The pattern should now be sanded in the lathe, and the location of the dowel pins determined, holding the pattern in the bench vise, as in Fig. 236.

It is important to bore the dowel-pin holes on the center line, and perpendicular to the joint of the pattern (see diagram, Fig. 238). This is done by measuring off $\frac{3}{4}$ and $3\frac{3}{4}$ in., respectively, from the end of the core print.

With a $\frac{1}{4}$-in. bit bore the holes as located, through one-half of the pattern and about $\frac{5}{16}$ in. into the corresponding half. The surplus ends with wood screws attached should next be removed, by using backsaw and chisel.

The dowel pins should next be made, and properly fitted and pointed, then fastened into the upper half of the pattern. The ends of the dowel pins should project $\frac{1}{4}$ in. from the dividing line of the pattern, in order to make a proper centering contact with the corresponding half.

The hexagonal should next be marked off and chiseled to proper shape as in Fig. 237, the pattern being held in the vise as in Fig. 236.

Sand the hexagonal, or any other part necessary before finishing.

PART III

LECTURE PROBLEMS

INTRODUCTION TO PART III

In presenting the subject of pattern making to engineering students and others interested in the manufacture of machinery, or other kinds of construction where castings are to be used, it is an advantage to know something of foundry practice, inasmuch as the pattern is used for making the impression in the mold into which the molten metal is poured to form the casting.

Patterns are classified into various groups, such as solid, or one-piece patterns, divided patterns, and others which are formed by the use of loose parts and core prints.

In order to plan the arrangement of a pattern, it should first be determined how it is to be molded and parted. This information is obtained from the drawing or blue print. The drafting and pattern departments have much in common, as the shape of the pattern is formed from the information obtained from the drawing. Hence the pattern becomes the first step in the actual production of the casting.

In many of the industrial plants, where the manufacture of machinery, automobiles, agricultural implements, and engineers' supplies takes place, an experimental department is maintained for the purpose of developing and perfecting the machine product before it is put on production basis. Obviously, this department would be closely affiliated with both the drafting and the pattern departments, and often comes under the same supervision of management.

To produce the actual casting, the pattern must first be made of wood, or some other suitable material, and from this pattern a mold is made in sand.

The molding sand should be of a cohesive nature and should be firmly packed around the pattern. The sand is held together by a boxlike frame called a molding flask, which is usually made up of two or more sections for convenience in parting the mold and removing the pattern.

When the mold has been completed the cope, or top portion of the flask, is lifted off and the pattern is drawn from both sections of the mold, leaving a cavity of its exact contour. The

sections of the mold are then assembled as before, and, a suitable opening for pouring the metal having been made, it is poured through and flows into the cavity, thus forming the desired casting.

When the casting has cooled it is removed from the mold by shaking it out of the flask. It is then cleaned and made ready for further commercial use.

The successful production of castings, therefore, lies largely with the pattern department, inasmuch as the arrangement of the pattern governs the conditions under which the casting is to be made. The following chapters and exercises will convey to the student a better understanding of the principles of pattern and foundry practice, as related to engineering problems.

Lecture 1

PATTERN CONSTRUCTION

The lecture problems presented in this course are intended to serve as an outline for class discussion and recitation.

The topics referred to are those of general interest, embracing the principles found in the field of industrial pattern practice.

The lectures can best be presented by having made on the blackboard an occasional sketch of the different details of the pattern as they are discussed. This tends to stimulate the interest of the student, as well as affords an opportunity to review the problem in its development.

The lectures should embody the essential features of pattern practice and their use in producing castings; reading and making shop drawings of the patterns to be made; the kinds of material used in their construction; and the use of power and hand tools according to their various needs as the construction of the pattern takes place; the reading of the drawing representing the object to be cast, the kind of metal to be used in making the casting, so that the oversize dimensions of the pattern may be determined.

This oversized measurement of the pattern is called "shrinkage allowance" and provides for the contraction of the metal when cooling.

To ascertain and provide for the making of finished surfaces on the casting: Finished surfaces are marked on the drawing by the letter *F*. When this information has been obtained, it is customary in the industrial plants for the pattern maker to lay out and make a full-sized working drawing of the pattern he is expected to build. This drawing should include the shrinkage allowance, as well as provision for finish where needed.

This brings us to the point where we must consider the way the pattern is to be molded, so that the proper parting lines are provided in its construction.

Next we will take up the tapering of those parts of the pattern, lying on either side of the parting line, which have a tendency to cling to the sand walls of the mold when the pattern is drawn from the mold.

This tapering is called *draft* and usually appears on the vertical portions of the pattern.

After the pattern has been built to the desired shape, whether it be very simple or complex, it must be carefully sandpapered and shellacked. This prevents the moisture of the molding sand from penetrating the surface and gives a perfectly smooth finish, which adds greatly to the convenience of the workman when the pattern is withdrawn from the mold.

PLANNING OF THE PATTERN

The object to be cast in metal is usually shown in a mechanical drawing with all finished sizes and other details fully described.

From this information the pattern is planned, care being taken to provide a pattern that will give entire satisfaction when used in making the impression in the sand mold for the production of the casting.

The pattern should be well constructed so that it will withstand the wear and hard usage to which it will be subjected in the foundry.

The dividing lines of the pattern should be clearly defined, and made to give positive divisions when used in making the mold.

Suitable provision should be made for the *draft* or tapering of any part of the pattern which has a tendency to cling to the sand surfaces of the mold. In complex cases this is sometimes overcome by the use of loose parts and special cores.

Finish allowance should be carefully observed in order that the casting may be properly machined. If such allowance is not provided for, the casting cannot be satisfactorily finished and may become a total loss. When possible all cavities in the casting should be made at the time the object is being cast, in order to avoid the additional expense involved when the internal openings are made by machine. These cavities are usually formed by the use of cores.

Core prints should be carefully located on the pattern according to the location of the cavity in the casting.

Core prints are represented by a different color than that of the pattern. They should be of the proper shape and size to insure a satisfactory bearing for the core when the core is placed in the mold. The pattern should at all times be kept in a first-class working condition, and from time to time should be

given a protective coating of shellac varnish. The core boxes should also be made and taken care of in the same manner as the pattern. While the pattern is used for forming the external shape of the casting, the core boxes are used for forming the cores which give the internal shape of the casting.

In manufacturing castings, many mechanical devices are now used which tend to simplify the many perplexing problems of pattern and foundry practice. Molding machines are extensively used in production work. The pattern is mounted on a dividing or stripper plate, which forms the dividing line of the mold. Metal patterns and core boxes are generally used in production work. The patterns are so arranged and grouped together as to insure a minimum of cost in producing the casting.

PATTERN DEFINITIONS

Patterns.—Patterns are usually first made of wood. Their production involves the making and shaping of various parts and the assembling of these parts into a workable object from which an impression can be made in a sand mold.

Core Boxes.—Core boxes are also made of wood. They are so constructed internally that when they are packed with sand a core is formed having the shape of the internal portion of the casting.

Core Prints.—A core print is *that* projecting part of a pattern which makes an impression in the sand mold into which the core is placed.

Pattern Draft.—Pattern draft is the tapering of any part of the pattern which has a tendency to cling to the sand mold when the pattern is drawn vertically or otherwise from the mold.

Shrinkage.—Shrinkage is the oversize allowance of the pattern, estimated according to the kind of metal used in making the casting.

For cast iron $\frac{1}{8}$ in. is allowed per foot.

For cast brass $\frac{3}{16}$ in. is allowed per foot.

For cast aluminum $\frac{3}{16}$ to $\frac{1}{4}$ in. is allowed per foot.

For cast steel $\frac{1}{4}$ in. is allowed per foot.

Finish.—Finish is the allowance made on the pattern to provide additional metal on any part of the casting which may require a machined or finished surface. The average allowance for:

Brass castings is $1/16$ in. per surface.
Iron castings is $3/16$ in. per surface.
Steel castings is $5/16$ in. per surface.

Master Patterns.—Master patterns are the originals from which metal patterns are cast. A double shrinkage allowance must be included in the master pattern to provide for the shrinkage of the metal pattern, as well as the regular shrinkage which takes place in the casting to be made.

STANDARD COLORS FOR WOOD PATTERNS

Through the U. S. Department of Commerce and the American Foundrymen's Association, the commercial color standard for wood patterns was adopted and became effective for new production February 10, 1930. The color markings for patterns and core boxes are as follows:

a. Surfaces to be left unfinished are to be painted black.
b. Surfaces to be machined are to be painted red.
c. Seats of and for loose pieces are to be marked by red stripes on a yellow background.
d. Core prints and seats for loose core prints are to be painted yellow.
e. Stop-offs are to be indicated by diagonal black stripes on a yellow base.

Some variations in shades of the above colors are permissible within reasonable limitations. The colors may be obtained by mixing suitable inexpensive pigments with varnish or shellac to produce the type of coating desired.

PATTERN MATERIALS

Lumber.—*White pine* is, in general, the ideal wood for patterns; though soft in texture it possesses strength and durability, and is easily worked into the desired shape of the pattern. This wood is straight in the grain, and when properly used in construction resists the tendency of warping.

Hard woods, such as mahogany, cherry, and black walnut, are best suited for making small patterns, and, being straight grained like pine, are not likely to warp. These woods are all easily worked and built into the various shapes desired to be made and will make a most durable and satisfactory pattern.

Drying and Care of Lumber.—The lumber used should be perfectly dry before an attempt is made to build it into a pattern.

Air-dried lumber is best because it does not crack or warp as readily as that which has been dried by a mechanical process.

However, it is not always feasible to use air-dried lumber because of the long time required to dry the wood by this method; therefore, kiln or mechanically dried lumber is more commonly used and when carefully prepared usually works out satisfactorily.

Storage of lumber is a very important factor in the production of good patterns. The lumber should be sorted into convenient piles, such as 1-, 1½-, and 2-in. stock.

In storing the lumber ½-in. strips should be placed between each layer, the strips being kept about 4 ft. apart and directly over each other as the pile increases in height. This will allow a free circulation of air and will keep the stock dry and prevent it from bending, twisting, or warping.

Nails.—In making the pattern the use of wire brads is essential as a means of holding together its different sections. The use of this particular type of nail prevents the distortion or splitting of various pieces used in the construction of the pattern. The lengths of the nails most commonly used are from ½ to 3 in., inclusive, and their thicknesses increases in proportion to their length.

When nails are driven into a hard surface of wood and they tend to bend, it is best to apply to the point of the nail a lubricant such as hard oil, wax, or tallow. This method is usually satisfactory. However, when such hard woods as maple, birch, mahogany, and cherry are to be used in the pattern, it is best to drill a small hole in the wood before nailing. In this way a more satisfactory result is obtained. Coated nails are those that have been dipped in a solution of resin, which gives them greater holding power. They are often used in constructing certain parts of the pattern where the nail heads will not appear on the finished surface. The head of the coated nail is much larger than that of the wire brad. If set below the surface of the wood it will cause a chipping or breaking on the finished surface of the pattern.

Wood Screws.—Wood screws, like wire nails, vary in length and thickness, and their use is governed by the conditions under which they are used for holding the pattern together. When using wood screws, a hole should be drilled about the size of the root of the thread. This removes that part of the wood which is to be occupied by the screw, leaving only sufficient material to allow the threads of the screw to become imbedded in the wood fiber; thus the full shearing strength of the wood will

serve to hold the strain put upon it by the screw. When used in end wood, additional strength can be obtained by placing a small amount of glue in the hole before the screw has been finally screwed into place.

When screws appear on the finished surface of the pattern, provision must be made for countersinking the screw head, or for plugging the opening which remains after the screw is in place. This is best accomplished by first boring the hole which is to receive the head of the screw to a depth of about ¼ in. below the finished surface. After the screw has been set in place, with the head well below the surface, the opening is filled by gluing a wooden plug, of the proper size, into the opening. The grain of the plug should run with the surface grain of the pattern. These plugs are made from a piece of flat stock, and are formed by the use of a plug cutter which is operated in the same manner as is an auger bit. When the plug has been properly glued into place, the top is then smoothed off level with the surface of the pattern.

Glue.—Glue is depended upon for making adhesive fastenings in constructing a pattern, and since much depends on the successful use of the pattern, the glue should be of the best.

Sheet or flake glue is best for pattern work and is prepared by dissolving in cold water. It should then be boiled in a steam or electric boiler and is considered ready for use when it has been thoroughly cooked into a liquid state of a consistency of heavy oil. Should the glue be too thick for convenient spreading, it should be diluted with water to the proper consistency. In many cases it is desirable to apply the glue very thin, and in all cases it should be thoroughly heated before using.

Glue is much stronger if used while fresh, as frequent heating and cooling has a tendency to dry out and destroy its strength. Hot glue, when mixed with a very small portion of raw linseed oil, will effectively resist the moisture of the molding sand; this mixture is highly desirable for use where the glue joint comes directly in contact with the sand.

Prepared liquid glue is convenient for use in the making of patterns that are not to be constantly subjected to the moisture of the sand, and when time will permit for the proper drying of this kind of glue.

Application of Glue.—When glue is applied, the surfaces of the parts to be glued together should be completely covered with a

thin film of the glue and immediately rubbed together; this tends to remove the surplus glue from the joint. Then the parts should be clamped together and the glue allowed to dry.

When hot glue is used, the time required for hardening does not often exceed a period of more than 2 hr.; however, if a longer time can be given, it tends to add to the strength of the glue joint. When prepared liquid or cold glue is used, from 5 to 8 hr. are required for drying before the piece of work can be successfully handled.

In the gluing of end wood, the pores of the wood should first be filled with a covering of white chalk, and then sized with a thin solution of the glue, which tends to fill the pores and prevents the wood from absorbing the glue that is used in making the joint.

Fillets.—The term "fillet" is applied to the concave surface formed where two parts of a pattern meet at a sharp angle. The fillet is usually made from wood or by gluing in a strip of leather that will form itself into the desired concave surface when properly applied to the pattern; or by the use of wax, when the shape is such that leather cannot be successfully used.

The use of fillets is illustrated in the angle-bracket exercise in bench work. A much stronger casting is secured by the use of fillets, as in the hardening of the metal the metallic crystals so arrange themselves that their lines of strength are perpendicular to the face of the casting.

Sandpaper.—Sandpaper is used to smooth the surfaces of a pattern after the tool work has been completed and also to rub down hardened shellac that has raised the grain of the wood and roughened the surface.

This tool, as it may be termed, consists of sharp sand (quartz or garnet) or pulverized glass which is glued to a paper backing. The grades of sandpaper, most useful to the pattern maker, are from No. 00 to No. 1. The latter is best for direct use upon the wood. Number ½ is best for varnished surfaces.

Sanding machines, used where the design of the pattern may permit, or sanding by hand should never be used to change a shape, but only for removing tool marks.

Varnish.—The application of a varnish is a very important factor in the production of a durable pattern. A pattern with the bare wood exposed would warp because of the moisture absorbed from the damp molding sand. Another disadvantage is that it would not draw easily, owing to the adherence of the

sand to the surfaces; hence the necessity of a varnish which overcomes these objectionable features and produces a hard smooth surface that is impervious to moisture.

In practice there are two general classes of varnishes: shellac and copal. The first, which is most commonly used, consists of gum shellac cut with alcohol and colored, if desired, by some coloring ingredient. The second, comprises the better grades of copal used by finishers.

By using several different colors of varnish it is possible to make a distinction between core prints and the body of the pattern, and also between patterns for different kinds of metal, such as brass, steel, and iron.

For spirit varnish, or gum shellac, a good grade of gum should be used, and likewise a good alcohol, in order to make the coating stand up to the work. Yellow flake gum shellac produces what is known as orange shellac when cut in alcohol. Different colors are produced by adding colored pigments or aniline dyes to orange shellac. Lamp black or bone black is best for black shellac. Other colors may be used such as red, green, and yellow. The use of these coloring mediums in shellac varnish seems to give it a better body and to increase its durability. Copal varnish, however, has a still greater durability, and, if allowed sufficient time to dry, will last much longer than several coats of shellac.

Application of Varnish.—Shellac should be applied in several thin coats, and each coat should be allowed to harden after which it should be rubbed down with old or fine sandpaper. The last coat of shellac, however, should not be rubbed down, as the dull surface tends to destroy the wearing surface of the shellac.

Mechanical methods, such as spraying on the shellac or varnish with a spray gun, similar to that used in automobile body finishing, are most successful and reduce the cost of pattern production.

Lecture 2

PRINCIPLES AND PROCESS OF MOLDING PATTERNS AND PRODUCING CASTINGS

From the industrial standpoint, it is essential to produce good castings at a minimum of cost; therefore, it is necessary to understand thoroughly the conditions under which patterns are molded, and how the castings are to be made.

The mold must be so made and so arranged as to permit the pouring of a casting that will be free from all blemishes, such as blowholes, sand holes, shrinkage cracks, and washed and blistered surfaces, which are practically all due to poorly made molds. Unsound castings must be scrapped, while rough and sand-covered castings require much time and expense for finishing.

It might be said that foundry practice is the making of castings by the use of patterns, core boxes, sand molds, and cores, and the pouring of the molten metal into the mold which forms the casting.

PRINCIPLES

The principles involved in making all classes of sand molds are:

1. Preparation of the sand by screening, tempering, and replenishing it with new sand, according to the need for porosity, strength, and cohesive qualities.
2. The selection and preparation of the molding flask and the use of such holding devices as cross bars, anchor irons, gaggers, soldiers, and nails.
3. The proper ramming of the cope and drag, parting, and venting.
4. The placing of gates, risers, shrinkage heads and vents, and the securing and placing of cores in the mold.
5. Clamping down the mold before pouring the metal, and the placing of pouring basins.

PREPARATION OF MOLDING SAND

Sand Tempering.—Tempering is the process of preparing the used sand by adding water and new sand and mixing it to a consistency that will retain the imprint of an object impressed in it. Care should be exercised at all times in preparing the

sand. If the sand is too damp, steam will be generated in the mold during the pouring of the metal and will in all probability cause a blow hole to appear in the casting.

MOLDING FLASKS AND ACCESSORIES

A molding flask consists of two or more framelike parts of the same length and breadth, with the height of each part varying according to the piece to be molded. The top is called the cope, the bottom the drag, and the center the cheek.

Flasks are made of wood, cast iron, or pressed steel. Iron and steel flasks are used in production work and where the castings are very heavy, while wooden flasks serve for special work and where the molding is of a lighter nature.

Flasks should be substantially made as they are subjected to severe wearing and rough use. They are held in their relative position by guide pins and sockets. The socket is placed in the lower or drag side of the flask, and the pins in the upper or cope side. When a center, or cheek section is used, the sockets and pins are arranged to fit both the cope and the drag side. They are called two- or three-part flasks, according to the number of sections.

Cross-bars.—The cope side of a large flask should be subdivided into small 6 in. compartments by placing cross-bars of a suitable shape to conform to the contour of the pattern which may project into the cope side of the flask. The lower edge of the bar should be beveled off to permit the sand to be packed more firmly.

The purpose of subdividing the cope is to insure a stronger surface of sand when the cope is lifted off the drag. This is done in order that the pattern can be withdrawn from the drag part of the mold.

Snap Flasks.—A snap flask is a small flask with a hinge on one corner and it is separated at the diagonal corner; when in use it is locked with a latch. It is used for small work where the pressure of the metal is not great. The advantage of this type of flask is that it can be removed immediately after the mold is made, and the molding operation repeated, the same flask being used.

A slip jacket is then placed over the mold to serve as a substitute flask and protect it until the metal has been poured.

Other designs of snap flasks are made with a fixed taper sufficient to allow the removal of the flask from the mold. A corresponding slip jacket of the same taper is used which hastens production for certain classes of work.

Bottom Boards.—A bottom board is a board as large as the outside dimensions of the flask on which the flask and patterns are placed before the mold is rammed. The board is cleated on the underside.

Gaggers.—Gaggers are L-shaped pieces of iron which are used with cross-bars to anchor the sand. The longer leg is placed squarely against the cross-bars and is held there by the pressure of the sand. These are usually made from stock about ½-in. in diameter.

Soldiers.—Soldiers are thin pieces of wood varying in length. They are dipped in clay wash and placed against the cross-bars to support hanging bodies of sand.

Nails.—Nails are used to reinforce sharp corners of the mold. After the mold has been made, the nails are pressed into place, the nail head being kept flush with the finished surface of the mold.

PROCESS

Ramming.—The purpose of ramming the sand is to make it stick in the flask and hold its shape against the flow of the molten metal. The degree of hardness of the packed sand is governed by the size of the mold, the condition of the sand, and the weight of the castings to be made. The sand should not be rammed too hard or the porosity of the sand will be lost and blow holes will be formed. Neither should it be too loosely rammed because the metal will wash or press out the sides of the mold. The bottom of the mold must be strong enough to hold the weight of the metal, the joints firm enough to withstand the handling, and the top soft enough to allow the gases to escape. Hence, the success in producing the casting depends largely on the ingenuity and skill of the molder.

Gates.—Gates are openings formed in the mold through which the metal is poured. The gate should be so placed as to allow the metal to enter the mold at the most advantageous place.

These openings are composed of two parts: The vertical part is called the "sprue" or "runner," and that part coming in direct contact with the mold cavity is called the "gate." These two parts, when properly made, form one continuous opening.

Gates vary in shape and size, according to the condition under which they are used, but for general practice they are usually made flat and shallow.

The top, or exposed part, of the sprue should be made to form a basin-like opening, which provides for a greater flow of metal as well as more freedom in the pouring of the casting. Should the casting be one of considerable size, a special basin should be constructed by building up with sand an enlarged opening, which would surround the top of the sprue. This makes ample provision for a steady flow of metal, as well as simplifies the pouring of the metal from a large ladle.

Risers.—A riser is an opening made in the cope side of the mold which serves as a vent and supplies additional metal for shrinkage as the casting cools.

The riser should be connected as nearly as possible to the heaviest and, when possible, to the highest part of the casting, and should be large enough to prevent the solidifying of the metal in it before the main casting has set.

In large castings the riser serves as an opening through which the metal in the mold can be agitated with a thin metal rod. This has a tendency to force the molten metal into all remote parts of the mold before it has cooled.

Venting.—Venting a mold is the perforating of, or making of passageways in, the cope and the drag to allow the escape of gas, air, and steam, which are generated in the mold when the metal is being poured.

If the mold is not properly vented, air pockets will form and retard the flowing of the metal into all parts of the mold.

Preparation for Pouring.—Before the metal is poured into the mold it is necessary to clamp the parts of the flask securely together in order to prevent the metal from forcing the cope out of position. When a large casting is being poured the mold should also be weighted down on the top side, for the clamps do not always hold.

In the pouring of large castings it is good practice to place a piece of tin over the sprue opening in the pouring basin. This will temporarily hold back the flow of the metal into the mold until a sufficient amount has accumulated in the pouring basin, after which the tin will be quickly melted by the heat from the molten metal, thereby releasing the flow of the metal into the mold.

MATERIALS AND THEIR USE

Molding Sand.—The molding sand must be porous in order to allow the gases to escape when the metal is being poured; it must be compact to hold the metal to the form desired; it should stand high temperatures without melting, and leave a clean, smooth surface on the casting. The important components of molding sand are silica, magnesium, and aluminum. The proportion of magnesium and aluminum must be small, or the porosity of the sand will be destroyed and the aluminum will melt and give a rough surface. These substances are valuable for the plastic and cohesive properties they give the sand.

Free Sand.—There are two kinds of free or clean sand: the sharp-grained river sand and the round-grained lake sand. The sharp-grained sand tends to blend together best and is preferred for core making. The core sands must not contain any substance that would cause them to cake when subjected to high temperatures, as this would make them difficult to remove from the casting.

Green-sand Molding.—Green-sand molding consists of making the impression of the pattern in molding sand, in a flask. The flask is a boxlike container which for general purposes consists of two parts; namely, the bottom or drag side, and the top or cope side. This method of molding is most commonly used because of its simplicity and its cheapness.

Dry-sand Molding.—In dry-sand molding, the mold is made with core sand and baked to form a hard clean surface. It is used in making bulky castings where the pouring of the metal might damage a green-sand mold. Metal flasks are used when the mold is baked within the flask, while larger types are made in sections and assembled.

Another phase of molding similar to dry-sand molding is used in manufacturing large castings where the surface of the mold is treated with a graphite wash, after which it is subjected to a heat treatment with a blowtorch, thereby causing the surface of the mold to become hard and strong.

Sweep and Dry-sand Molding.—When making a casting for a large flywheel, a rope pulley, or similar circular work, a very satisfactory mold can be made from dry sand (similar to core sand).

It is not necessary, however, to make a complete mold by using a pattern for the impression, as might be used in ordinary

cases, but rather, it is made up in dry-sand sections and assembled according to the design of the casting to be made.

To accomplish this method of molding, it is necessary first to make a cross-section drawing or other necessary sketches, which should be made to represent the full size of the casting, including shrinkage of metal and finish, if any.

After this has been done, the sweeps are made for forming the bed, or foundation on which the sections of cores are to be placed, as well as the core boxes for the hub, arms, and rim.

The dry-sand sections of the mold are formed in the various boxes similar to a core, after which they are baked, and when complete are built into the shape of the mold.

Loam Work.—In loam work, the mold is constructed of bricks and faced with a clay mortar which is shaped by means of sweeps or patterns, after which it is dried by means of circulating the heat from a furnace through the mold. This is used for heavy castings where a green-sand mold might be distorted or where only a few castings are to be made of some bulky object.

Loam.—Loam is a mixture of molding sand and clay. It is desirable for the loam to contain alumina, iron, and silica, because these substances are refractory, that is, they can withstand a high temperature. Substances such as lime, pyrites, and alkalies are objectionable in the loam and should not be used for this kind of work.

Loam Plaster.—Loam plaster is a poorer but more cohesive grade of loam. It is used in loam molding as a plaster for setting up the brickwork, the first coating of the mold, and sealing the joints.

Parting Material.—Parting material is a fine-grained sand, brick dust, burnt sand, or pulverized blast-furnace slag, which should be free from all materials that draw or retain moisture. It is used on the parting line of a green-sand mold to prevent the cope from sticking to the drag.

Facing Sand.—Facing sand is a mixture of high-grade molding sand which is mixed with carbon dust. This material is placed next to the pattern to form a facing for the mold, and the balance of the flask is then filled with used molding sand. The purpose of the facing sand is to form a smooth surface and to prevent the mold from being washed away by the flow of the molten metal when it is poured into the mold.

Facing.—Facing is a material which is applied to the surface of the impression after the pattern has been withdrawn. The purposes of the facing are to prevent the molding sand from being burned, to produce castings with a smooth finish, and to reduce the cost of cleaning.

Graphite, Charcoal, Coke, and Sea Coal.—Graphite, charcoal, coke, and sea coal are some of the materials most commonly used for facings.

These materials are used because they will resist the washing action of the molten metal, will adhere to the face of the mold, and are not easily burned.

Fire Clay.—Fire clay is nearly pure aluminum oxide and when dry produces a refractory or heat-resisting surface. This material is used for lining furnaces, ladles, or vessels which are subjected to intense heat.

Clay Wash.—Clay wash is a mixture of fire clay and water in such proportions that a film of clay will be left on any object dipped into it. It is used for wetting gaggers, cross-bars, and the inside surfaces of the flask.

CORE MAKING

Cores.—A core is that part of the mold which forms the internal shape of the casting.

Cores are made from a high-grade refractory sand mixed with a binder such as linseed oil, molasses water, or flour. The purpose of the binder is to produce a cohesive mixture which when subjected to heat by baking in an oven will harden into the desired condition for use in foundry practice.

A core is formed by packing the sand into a core box. The core is then removed from the box and baked in an oven. During the baking process the core is supported on a metal plate which is shaped to suit the contour of the core.

The core is held in the mold by means of the projecting portion of the core; this is made to correspond to the shape of the core print which is attached to the pattern.

Binding Materials.—Core-binding materials, such as ground resin, molasses water, flour, and linseed oil, should have a sufficient cohesive power to hold the grains of sand together until the metal has formed around the core. During the cooling period of the casting, the binder should be slowly burning out to allow for an easy removal of the core from the casting.

Reinforcement of Cores.—When the natural strength of the core is not sufficient to stand the pressure of the metal, it is reinforced by embedding wire or iron rods into the core during the process of construction. The rods vary in size and shape according to the requirements of the core; and at no time should these supporting rods be placed in the core where they may become exposed to the molten metal.

Core Venting.—Cores are vented by inserting a suitable sized venting rod into the core before removing it from the core box, thus leaving a vent opening.

When cores are of an irregular shape, where a straight opening cannot be made, it is customary to bed into the core, during construction, a wax cord which will leave an opening of its size and shape after it becomes absorbed by the heat of the sand during the process of baking the core.

Large cores are made porous in the center by means of a cinder filling, from which other openings are made to carry off the gases. The core sand is first spread over the surface of the core box and then the cinder filling, after which the core is completed by filling in the box with the regular core sand.

Core Baking.—Core ovens vary in size according to their special use.

The oven should be large enough to admit the carriage, on which the green cores are placed for baking. The carriage is rolled into the oven and the baking process begins.

Pyrometers are used to register the temperature of the oven as well as to record the time required for baking. This method insures a more even baking of the core and adds much to the better production of the casting.

Core Finishing.—After the core has been baked, it should be given a coat of graphite blacking. This gives the core a much smoother finish and improves the surface of the casting.

Lecture 3

SOLID TYPE OF PATTERN

ILLUSTRATING USE OF BALANCED CORE PRINT

The designs of castings differ greatly, likewise the patterns in their form of construction.

It may be that the casting to be made is one of a very simple design such as a disk, or a cube, or it may be one of a more complicated type, such as a gasoline-engine cylinder block.

In each case the pattern must be complete in every detail in order to produce a satisfactory casting.

When the casting is made for a disk, or cube, or some such object, it is customary to make the pattern to represent the exact shape of the casting. This type is called a "one-piece" or "natural" pattern.

Other types of castings which may have a hollow or open center and are of such a design that the pattern could not be drawn from the mold, if it were made to be an exact likeness of the casting, are constructed by placing a core print on that part of the pattern where the opening is to appear in the casting.

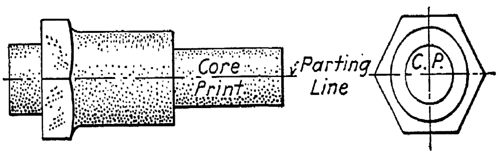


FIG. 301.

This second type might be classified as a compound pattern, which involves the use of a sand core when making the mold.

When this type of pattern is molded, an impression of both pattern and core print is made as one, the pattern representing the casting, and the core print the location of the opening.

The impression of the core print also provides a means of holding the core in place within the mold.

An example of this type of casting requiring a core is illustrated in the oil-cup pattern (Fig. 301).

This design of pattern, as shown here, is known as a one-piece or solid type construction, and for small castings is considered the best design, owing to its durability. For larger types this pattern should be divided in two parts, as in Fig. 238.

When one or more patterns are molded in the same flask, it is customary to use a parting board which is made to have the contour or surface of the board conform to the parting line of the pattern, and serves as a means of holding the patterns in their

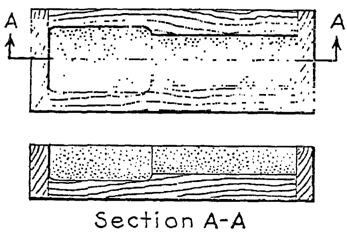


FIG. 302.

proper place while the sand is being packed in the flask (see Figs. 303 and 304).

When a core is supported in the mold, from one end only, as in the case of the oil cup (Fig. 306), it is called a "balanced" core.

The core print on the pattern must be so arranged that the portion of the core, corresponding to that of the core print,

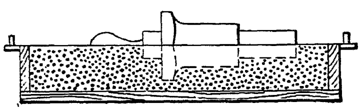


FIG. 303.

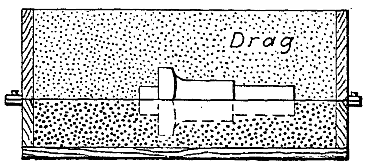


FIG. 304.

will not only balance that part of the core which extends into the metal cavity, but will also prevent it from rising in the mold when pressure is exerted from below by the inflowing metal when the pouring of the casting takes place.

Likewise, the sand core must be so constructed as to withstand the pressure of the metal when it is poured. This is accomplished by embedding small reinforcing metal rods in the core when it is being rammed in the core box.

It is well to remember that the material which must hold the core in place in the mold is only loam, or, as it is technically called, sand. The success of holding the core, therefore, depends much on the design of the core print, which should provide an ample surface to make the core secure against the weight and action of the molten metal during the process of pouring.

To make a core, it is first necessary to have a core box, which is constructed with an opening or cavity corresponding in shape to that of the core desired (see Fig. 302).

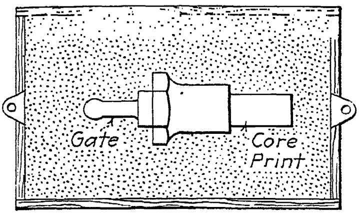


FIG. 305.

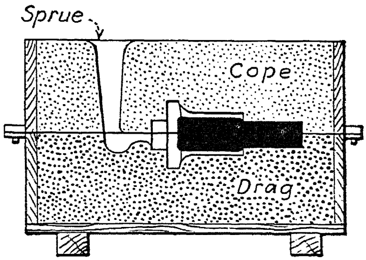


FIG. 306.

The core box is sometimes called a core mold, as it is used for giving shape to the core. When cores are to be of a symmetrical shape, such as a cylinder or the shape used in making the oil cup, it is a common practice to make the core box for one-half only, as in Fig. 302.

In making the core in this case it is necessary to make two halves, and when dried by baking they are fastened together by means of a paste, thus forming the complete core. This method is commonly used in practice, and it illustrates the elementary principles of the making and use of a dry-sand core.

STEAM-ENGINE CYLINDER-HEAD PATTERN

ILLUSTRATING LAMINATED METHOD OF CONSTRUCTION

Another type of solid or one-piece pattern is found in the cylinder head (Fig. 307).

Patterns of this description should be constructed in such a way as to retain their proper shape at all times. If this type of pattern were made from a solid piece of stock, in all probability it would shrink, and warp out of shape, owing to the atmospheric conditions, as well as the absorption of moisture, when embedded in the sand mold.

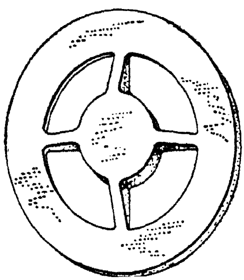


FIG. 307.

To avoid such distortion of the pattern it is best to use the laminated method of construction. This method consists of building up the pattern in layers, rather than from one solid piece, each layer being made up from a suitable number of segments which are carefully fitted and glued together to form the shape and diameter of the pattern.

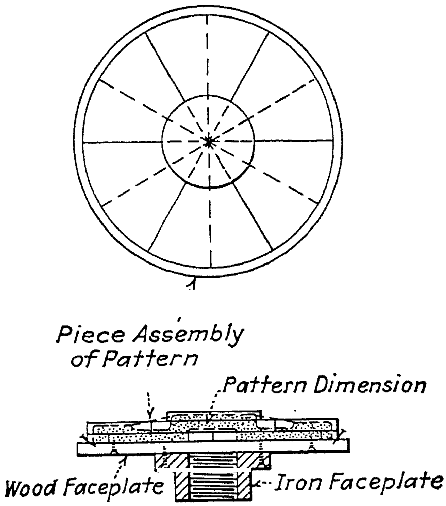
The joints of the segments in each layer should be *staggered* or *overlapped*, alternating with the preceding layers as they are built into place.

The segments are cut from stock of the proper thickness and size according to the pattern layout, allowing sufficient material for fitting, turning, and finishing.

To assemble the segment parts into the desired shape of the pattern, it is first necessary to have a wooden face plate which forms a part of the lathe on which the pattern is to be made. The first layer of segments should be fitted and the ends glued, and attached to the face plate by means of wood screws and wire brads as indicated in the cylinder-head pattern (Fig. 309).

After the first layer has been properly arranged on the face plate, the surface is then faced off with a side-cutting scraping tool. The succeeding layers should then be fitted and glued into

place, according to the number required to complete the design of the pattern.



FIGS. 308 and 309.

The segments are held in place temporarily by means of brads which are temporarily used to hold the segments in place while

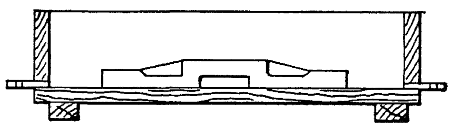


FIG. 310.

the glue is drying. This permits the continuous construction of the pattern (see illustration of this method in Fig. 309).

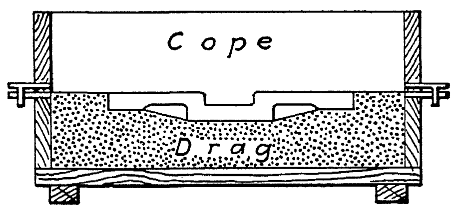


FIG. 311.

When the glue has dried, the brads should be removed to permit the turning down of the rough construction of the pattern

to its finished size. The wood screws serve as a means of holding the pattern in place on the face plate, during the interval of turning.

The outside surface and diameter of the pattern should be turned first; the pattern is then reversed in order that the opposite side may be completed.

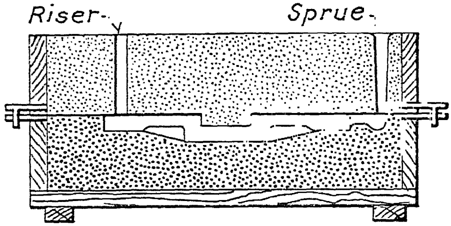


FIG. 312.

This operation is done by counterboring a recess into the face plate which will receive and center up the hub of the pattern, as well as supply a friction contact to hold the pattern in place on the face plate.

When the turning of the pattern has been completed, the ribs are attached in their respective places.

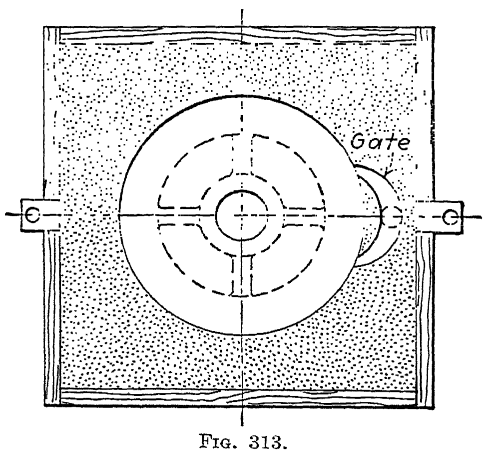


FIG. 313.

Other examples of this type of construction will be found in the marine-piston pattern (Fig. 314) as well as in the flanged-ring pattern (Figs. 319 and 320).

The pattern should then be given a protective coat of shellac, after which it is sanded and the fillets are set into place.

Lecture 5

MARINE-PISTON PATTERN

ONE-PIECE SOLID TYPE, SHOWING HANGING COPE

The marine piston is another type of a one-piece pattern, and it suggests the plan of using various layers of segments of different diameters in building this conical-shaped type of pattern.

When the cross-section drawing has been made to determine the number and thickness of the different layers of segments to be used, as well as to ascertain the change of diameter of each layer, the task of constructing the pattern would next take place and this is carried out somewhat on the same plan as in the cylinder head.

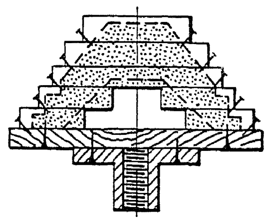


Fig. 314.

Assuming that the face plate on which the pattern is to be built has been selected and is ready for use, the next step would be to prepare the various courses of segments which are to be used in the construction of the pattern.

When building a pattern of this type it is customary to provide a small amount of surplus stock on both edges of the segments, so that the rough pattern can later be turned down to the required dimensions.

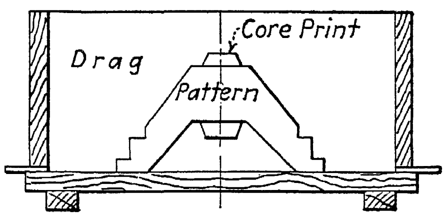


Fig. 315.

The first layer of segments to be used are those of the largest diameter. These are fastened to the face plate by means of wood screws, as the segments are fitted and glued together.

When the first layer has been completed, the surface should be faced off on the lathe, in preparation for the next layer, and at

the same time the outside diameter of the second layer should be marked on the surface of the first, thereby keeping the layers concentric with the center of the pattern. This method is repeated as the various layers are built into place, care being taken to break the joints of the segments, in each layer.

Brads are temporarily used to hold the segments in place while the glue is drying, as this method allows the construction of the pattern to progress before the glue has set.

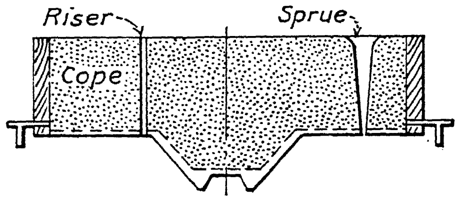


Fig. 316.

The brads are driven through the outside edge of the segments at an angle of about 65 deg. to the face of the segments.

The heads of the brads must be exposed for convenience in removing them later from the pattern when the glue has set, but they should be kept clear of the top surface of the segments to avoid coming in contact with the turning chisel when the surface is faced off.

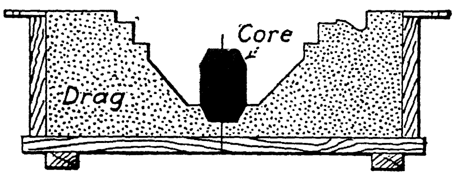


Fig. 317.

When the rough pattern is ready for turning down to the finished size, and all brads have been removed, the outside surface of the pattern is first made. When this has been completed, the pattern is removed from the face plate by removal of the wood screws.

Next the face plate is counterbored to fit the small end of the pattern. This end is then set into the counterbored opening and held in place by means of a friction fit, as well as by wood screws.

The inside portion of the pattern is then turned to the finished size, a templet being used for a gage, and when complete is removed from the face plate and lathe.

The core prints are made from a separate piece of stock and, when properly centered, are attached by means of brads.

The pattern is molded so that the weight of the metal is entirely in the drag side of the flask.

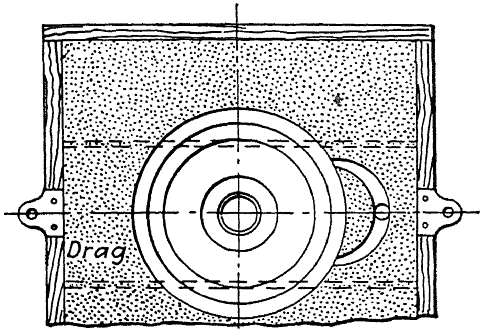


Fig. 318.

The cope side of the flask is subdivided into small compartments by means of cross-bars which hold the unsupported and hanging sand in place within the mold, as shown in Fig. 316. In extreme cases, it is customary to reinforce the hanging sand with special gagger irons. This keeps the sand from breaking off when the metal is poured into the mold.

Lecture 6

FLANGED-RING PATTERN

ILLUSTRATING METHOD OF CORING BOLT HOLES THROUGH VERTICAL AND HORIZONTAL SECTIONS

The flanged ring, illustrating the method of using segments, and coring a number of bolt holes through the vertical and horizontal sections of the casting, is still another type of one-piece pattern which is built in laminated form to give the best results in constructing the pattern, as well as to preserve its ility.

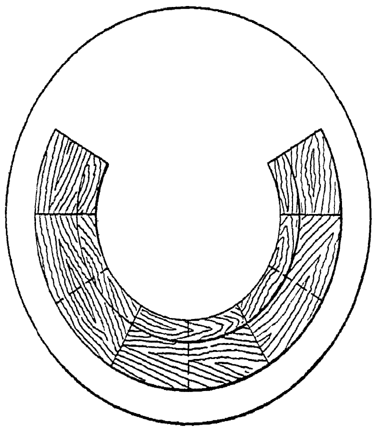


FIG. 319.

in the the

layer. This is done to provide sufficient stock for making the fillet which is a part of the second layer of segments.

The average thickness of each layer in work of this type would be about ⅝ in., and in planning the cross-section drawing, it is best to make it pattern size. This will afford a better

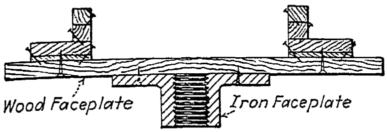


FIG. 320.

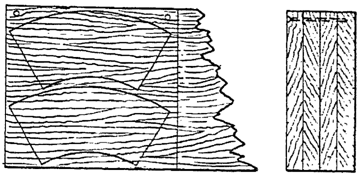


FIG. 321.

opportunity of determining the thicknesses of the various layers of segments to be used.

When the rough construction of the pattern has been completed, and sufficient time given for the glue to dry, the brads should be removed. The pattern should then be attached to the lathe by means of the face plate and when the tool rest and

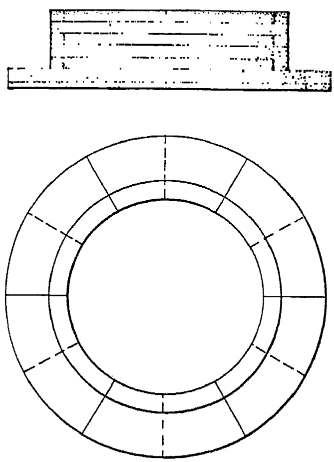
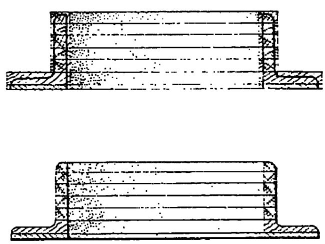


FIG. 322.



Finished Pattern

FIG. 323.

other parts of the lathe have been adjusted, the pattern should be turned down to the proper size.

In turning down the pattern, it is best first to take a roughing cut on all surfaces. This gives a better balance to the piece and allows it to rotate more smoothly in the lathe while being

finished to the final measurements. The inside of the ri should be finished next, proper allowance being made for tl draft on the vertical portion of the ring. The outside

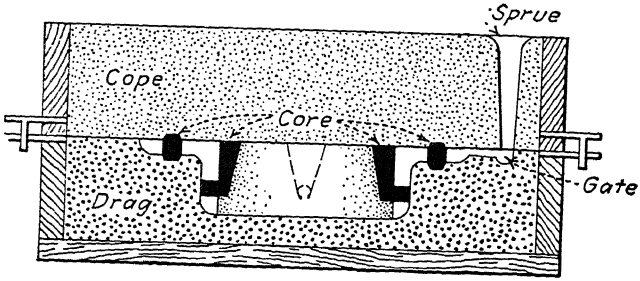
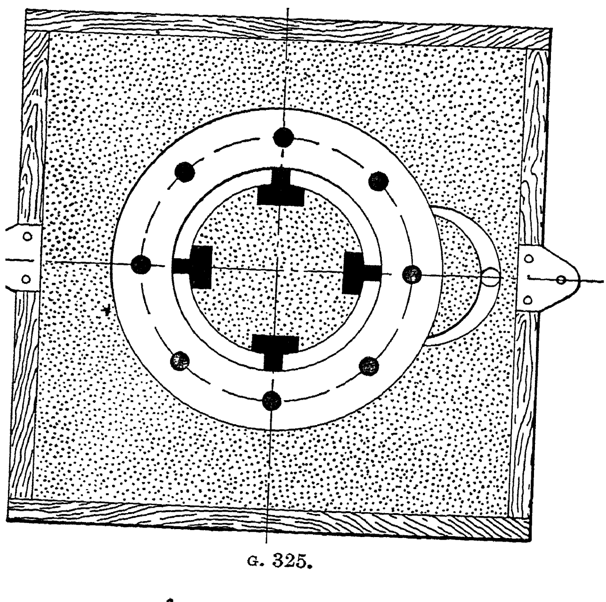


FIG. 324.

pattern is then turned to size, the fillet being properly made with a round-nose scraping tool, while the rest of the turning is done with a right- and left-hand scraping chisel or diamond-point tool.



G. 325.

ıg of
bolt h
tapered blocks of a

on the small end to correspond to the diameter of the hole. These are fastened with brads on the inside of the vertical wall of the pattern at the places where the bolt holes are to appear in the casting. The application of this method of coring in practice will be found in the bench exercise on the angle bracket (Fig. 21) and core box (Fig. 26). The pattern is molded in the usual two-part flask; the drag containing the entire pattern and the cope serving merely as a sand cover with proper provision for pouring the metal. When the cope is lifted off and the pattern

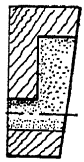


FIG. 326.

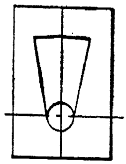


FIG. 327.

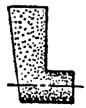


FIG. 328.

removed from the mold, leaving its impression, it will be noted that the impressions of the core prints form a suitable means of holding the core in place, as shown in Fig. 324. The projecting end of the core, which represents the size of the hole to be made in the casting (Fig. 328), must not exceed or be less than the thickness of that part of the casting through which the hole is to be made. Great care, therefore, should be exercised in making the core box for this, or any other cored work to be used in making openings in the casting (see Figs. 326 and 327). Further details of this method of construction should be discussed to give a more complete and varied knowledge of the building and use of patterns of this general type in so far as they may apply to the topic under discussion.

Lecture 7

SMALL FLANGED CYLINDER

ILLUSTRATING DIVIDED TYPE OF PATTERN AND CORE BOX

Small patterns of this divided type are represented by the flanged cylinder. Figure 332 should be made from solid stock, while larger types are constructed by means of supports and staves.

When making a pattern for a small flanged cylinder, the stock used to form the pattern should be long enough to allow

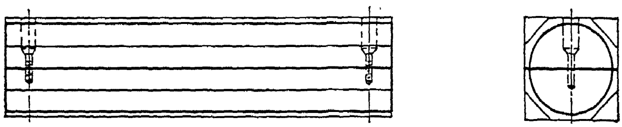


FIG. 329.

for the core prints as well as fastening the two pieces together at the ends by means of wood screws (Fig. 329).

The flanges for the cylinder pattern are made from separate pieces and attached to the cylinder, after it has been turned to size (Fig. 330), provisions being made on the cylinder for

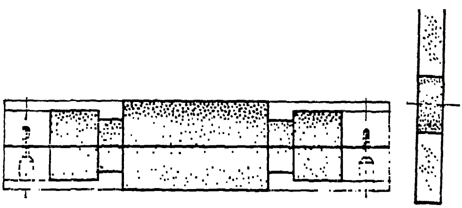


FIG. 330.

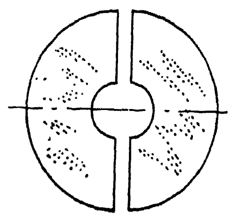


FIG. 331.

attaching the flanges by means of a recess groove which holds the flanges securely in place.

When the cylinder has been turned, the end screws are removed and the pattern temporarily taken apart to allow for the attaching of the flanges. This is done by means of glue and a wood screw which passes through the cylinder and into the flange (Fig. 332).

The flanges are made up in semicircular parts and should be thick enough to provide for the fillets formed at the intersection of the flange and the cylinder surface.

After the flanges are properly attached on the cylinder, the two halves of the pattern are again assembled and the flanges are then turned down to size. The pattern is then sanded and removed from the lathe.

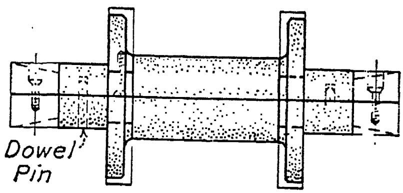


FIG. 332.

Dowel pins for centering the two halves of the pattern are placed in the core prints. This is done by boring a hole of the proper size through the center of the core print of one half and part way into the other half. The dowel pins are then put in place. The surplus stock is removed from the ends of the core prints and the ends finished.

A core box is necessary along with the pattern in making the mold. There are two general types of core boxes in use,

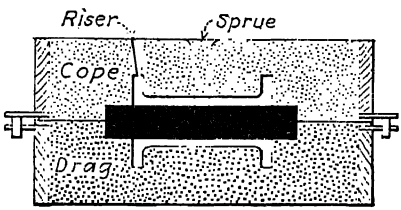


FIG. 333.

as shown in Figs. 336 and 337. The closed core box (Fig. 336) is used for short cores of small diameter, where very little venting through the cores is necessary. This type of core box is filled with sand from the end, and the core is removed from the box by dividing the box at the center line.

The half core box (Fig. 337) illustrates the type used for larger cores. With this type two half-cores are made, and when baked they are fastened together with paste to form the complete core. With this type of core, the venting is a simple matter,

requiring merely a groove of sufficient size which runs the full length of the core.

Patterns that are of a symmetrical design, such as the flanged cylinder (Fig. 332), and that can be parted along the center line are classified as two-part patterns.

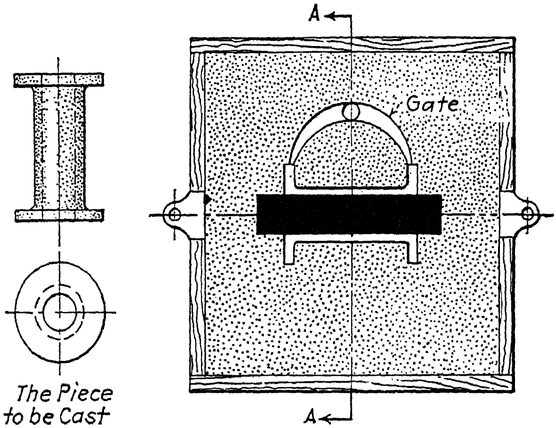


FIG. 334.

The advantage of making the p to mplify the molding of the pattern.

In the case of the cylinder we find that it must be molded horizontally and will require a horizontal core, which is held in position in the mold by means of a core print formed on each en of the pattern

When molding this type of divided pattern, one-half of the pattern is placed on the bottom board. This is called the first position.

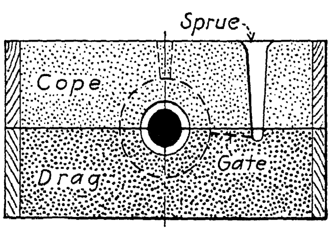


FIG. 335.

The drag side of the molding flask is then placed on the board and around the pattern, forming the space in which the first half of the mold is made.

When rammed, this part of the

halves of the pattern are kept in alignment by means of dowel pins (see Fig. 332).

After the necessary parting has been made and the riser and the gate pin have been placed in position, the cope side of the mold is finished by packing in the sand.

After the cope is made, it is lifted off the drag with the cope half of the pattern embedded in it, and held there by the friction

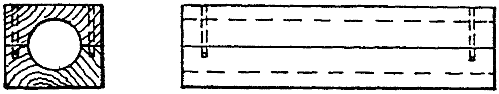


Fig. 336.

of the sand around the pattern. The two halves of the mold will appear the same, except for the riser and the sprue pin in the cope (Fig. 335).

The next step is the removal of the pattern from the mold. It is good practice first to moisten the edges of the sand around the pattern. This keeps the sand from drying out after the pattern is removed, and insures a sharper edge of the mold cavity along the dividing line. To remove the pattern, a draw

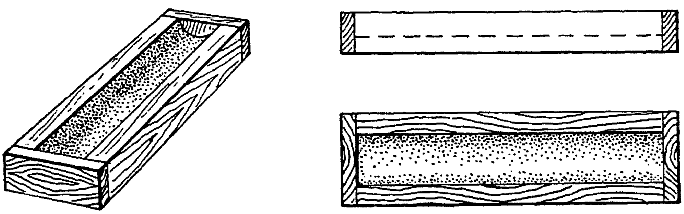


Fig. 337.

pin is attached at the most advantageous point and vibrated slightly to free the pattern from the sand walls of the mold.

The pattern is then carefully drawn out leaving its exact contour in the sand.

Next the gate is cut along the parting line of the drag side, connecting the mold cavity and the opening formed by the sprue pin. The core should now be placed in the drag side of the mold. It is held in its proper position by means of bearing cavities formed by the core prints on each end of the pattern.

The cope is then placed on top of the drag and, when clamped in position, is ready to receive the molten metal (see Figs. 334 and 335).

The metal when poured will enter the mold cavity, thus forming the desired casting.

Lecture 8

LARGE FLANGED CYLINDER

ILLUSTRATING HOLLOW TYPE OF CONSTRUCTION

For a light and durable form of construction, patterns of this type are usually made in two halves, and should be built up to have a hollow center. This is accomplished by assembling staves or strips of wood about 2 in. thick which run the entire length of the pattern and are fastened to cross-members of a certain shape. These are placed at each end, and at convenient

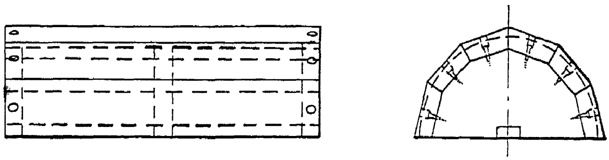


FIG. 338.

intervals, giving rigidity to the structure. The staves and cross-members are glued and screwed together in the construction of each half. When necessary, additional strength can be added to the supporting cross-members by embedding a strip of wood which runs the entire length of the pattern (see Fig. 340).

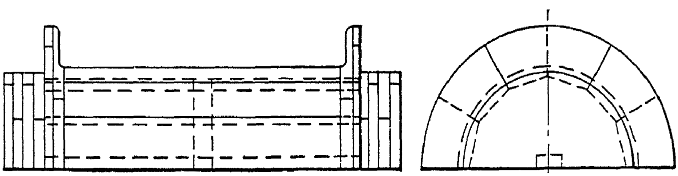


FIG. 339.

When the two halves have been completed, they are centered together with dowel pins and made ready for turning down to the finished size.

Metal plates which serve as bearing centers as well as a means of holding the two halves of the pattern together during the process of turning are then screwed in place on each end of the cylinder. The pattern is then placed in the lathe for turning.

When flanges are included in the design of the cylinder, a shoulder should be formed on each end of the pattern to receive the flange (see Fig. 340).

The flanges are built up of segment parts to the desired thickness and turned to proper size on a face plate. In building the flanges care must be taken to have the division of each flange correspond to that of the cylinder. When complete they are then removed from the face plate and fastened to the cylinder (see Fig. 340).

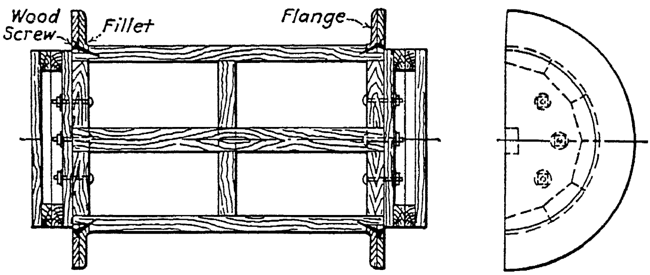


FIG. 340.

The core prints are made in a manner similar to that in which the flanges are made, except that the ends are enclosed, which affords a means of fastening them to the cylinder as well as forming a finished end (see Fig. 340 for assembly of parts).

The core box may be made to represent a half core, or in special cases the core may be made by a process of sweeping which requires a form to represent the diameter and length of the core to be made. Cores of this type are usually made in two halves and are fastened together with paste.

In making such patterns, however, it is first necessary to make a full-size end view of the cylinder, showing in detail the parts to be used in its construction.

Lecture 9

FOUR-WAY, FLANGED-TEE PATTERN

The four-way, flanged-tee pattern is used to illustrate the method for making a three-part pattern and mold. The main part of the pattern is built up in the same manner as shown in the cylinder (Fig. 340). The branches are made as separate parts and should be attached to the main cylinder in completing the pattern. The plan of constructing the main portion of the pattern affords a good opportunity for fastening the branches in place, due to the hollow type of construction.

When the principal parts including the flanges have been built into place, the loose flange is made, and when finished it should fit into the shoulder formed on the vertical branch (see Fig. 342). By this method the flange is held in a fixed position, although it is not permanently fastened to the pattern.

The core box may be made up in half, to give a tee core which is supported in the mold by means of the three core prints found at the parting line *A* (Fig. 342). The vertical section of the core is made in a separate core box and is provided with a stop-off piece which is used in forming the end of the core where the intersecting points come together.

In molding the pattern the drag side is first rammed, and then turned over to receive the cheek or center part. The parting is then made and the sprue pin set in position as in Fig. 341. When ramming the cheek side, it is best to remove the loose flange until the sand has reached the shoulder on the vertical branch. The flange is *then* set in place and the molding sand carefully packed underneath it and up to the level of the top surface, at which point the parting of the cope is made.

The cope is next made which gives an impression of the top core print and upper side of the flange (see Fig. 342). The sprue pin is then drawn which leaves an opening through the cope and the cheek side of the mold and directly behind the center of the loose flange at *AA* (Fig. 342).

The pattern is removed from the mold by first lifting off the cope. This exposes the face of the loose flange and the core

print. The loose flange is then removed and the cope set back in place on the cheek. The cope and the cheek part of the mold are then clamped together to form one unit. The cheek portion of the pattern is temporarily anchored in place to prevent its shifting in the mold during the process of lifting this unit off the drag.

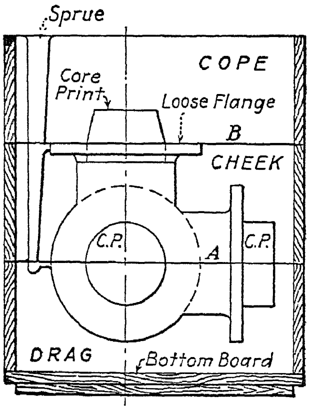


FIG. 341.

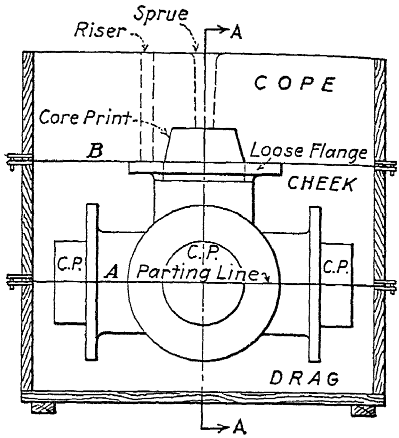


FIG. 342.

The anchored part of the cheek side of the pattern is next released and then removed from the mold. The drag side of the pattern must now be removed. The core is then set in place and the cheek and the cope sides reassembled on the drag which leaves the mold ready for pouring. It should be understood that the customary plan of venting and placing risers at the most advantageous points in the mold would be included in this problem.

Lecture 10

COMBINED INTERNAL AND EXTERNAL CYLINDERS

ILLUSTRATING METHOD OF MAKING GASOLINE-ENGINE CYLINDER BLOCKS

Much may be said about gasoline-engine cylinder blocks, as to their variation in design and their method of manufacture. In most cases, however, the cylinder block is designed to have the cylinder walls of the casting kept cool by means of a water jacket which is cast in such a way as to provide a means of circulating the water around the cylinders and in this way keep the motor block from overheating.

The greatest difficulty in casting a cylinder block is found in making ample provision for supporting the cores which form

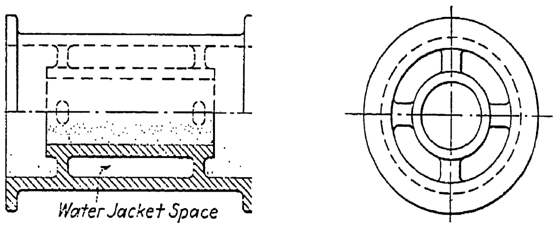


FIG. 343.

the water jacket, and in connecting the outside and inside walls of the castings. Suitable provision must also be made for venting the cores.

To illustrate, let us consider that a casting is to be made to represent two ordinary cylinders of different diameters placed concentric to each other and having walls of ½ in. in thickness with a variation of 3 in. in their outside diameters. The two cylinders are to be joined concentrically by means of four 1 in. studs at each end of the internal cylinder, and placed 90 deg. to each other (see end view of cylinder casting, Fig. 343).

For convenience in illustrating this problem, the cylinder having the smaller diameter is called the internal cylinder, and the larger one, the external cylinder. The internal cylinder is to

be 6 in. in diameter by 12 in. in length and the external cylinder is to be 9 in. in diameter by 18 in. in length.

The pattern for such a casting as this would be made in two parts having the parting line along the axis of the cylinder (Fig. 344). The stock used should be prepared so as to include the length of the core prints on each end of the cylinder, as well

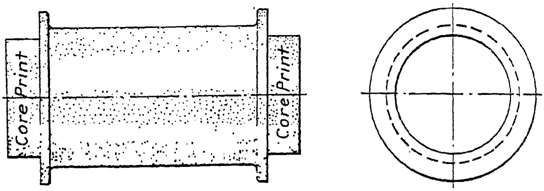


FIG. 344.

as the surplus for holding the two parts of the pattern together while it is being turned in a lathe.

The pattern for the external cylinder should be made first; and when completed, that part representing the metal should measure 9 in. in diameter by 18 in. in length. The core print on each end of the cylinder should be 8 in. in diameter by 3 in. in length giving an overall measurement of 24 inches.

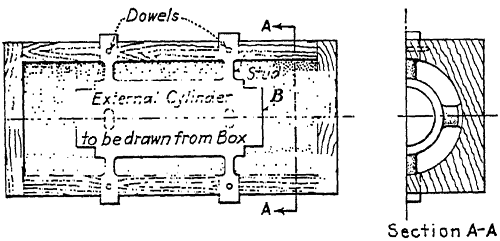


FIG. 345.

Next the internal cylinder is made in the same manner as was the external, and when completed it should measure 6 in. in diameter by 12 in. in length with core prints 5 in. in diameter by 3 in. in length, giving an overall dimension of 18 in.

When making large cores of cylindrical shape, it is customary to make them in two parts divided along their axis. This is an advantage in baking the core, because only a flat metal plate is required on which the core is placed; and in making the core, a half core box should be used.

CORE BOXES

The wood for the core box should have its grain running lengthwise and should be the same length as the external cylindrical pattern which is 24 in. The block of wood from which the core box is made is glued up in the rough from suitable stock to give a piece 6 by 12 by 24 in., leaving only enough surplus to insure the proper shaping of the core box (see Fig. 349). When completed the core box should have a semicircular concaved opening 8 in. in diameter running the full length of the box.

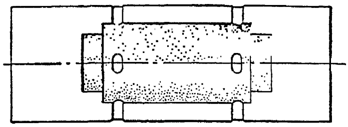


FIG. 346.

The ends are enclosed with two pieces of stock about ¾ in. in thickness and should cover the entire ends of the core box.

Next one-half of the internal cylinder is used, and to it is attached two cross-pieces of wood which are set flush with the flat surface of the cylinder and according to the desired location in the drawing. These two pieces should be long enough to extend slightly over the outside width of the core box and should be of proper width and thickness to permit the shaping of the studs

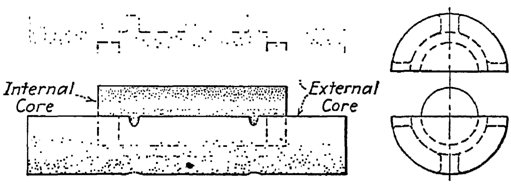


FIG. 347.

(see section *AA*, Fig. 345). When this has been done, four notches are made in the top edge of the core box to receive the projecting ends of the cross-pieces which carry the internal cylinder as well as hold it concentric with the opening in the core box. Dowell pins are placed through the projecting ends and into the sides of the box to keep the internal cylinder from shifting out of place while the core is being rammed.

Next the two corresponding studs are made in two parts and attached in place, one-half being fastened to the under side of the cylinder and the other to the surface of the core box at that

point where they come in perfect contact with each other, thus forming the completed stud.

The half core box when completed and ready to be used in forming the core will have the internal cylinder concentrically set within it, and held in place by means of the projecting studs (Fig. 345).

The space in the core box is then filled with core sand which is tamped around the internal cylinder. The internal cylinder

FIG. 348.

is next withdrawn from its position in the core box. The desired cavity being left in the center of the main core (Fig. 346). This cavity corresponds to the outside shape of the internal cylinder and provides a space into which the internal cylinder core is placed (see Fig. 346).

The placing of the internal cylinder core is the next operation. This core is set into the cavity made by the impression of the core prints on the internal cylinder (see Fig. 347).

The upper half of the main core must now be placed over the lower half, enclosing the internal core within (Fig. 347). All

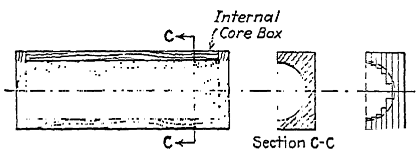


FIG. 349.

joints of the cores must be well sealed and fastened together. The complete core assembly is then placed into the core print cavities of the external cylinder mold, and the cope is placed over the drag. This completes the mold and its cavity is ready
l with metal

rs the mold through the usual form of gate, and flows into all parts that are not already occupied by the cores. The internal part of the cylinder receives the metal through the openings which form the studs. When the metal has cooled, the sand mold and cores are removed, leaving the casting as illu

The preceding paragraphs in this problem outline the principles of making the internal cylinder and water jacket, within the main core, and will give a clearer understanding of the plan for making a gas-engine cylinder block such as shown in Figs. 351 and 352.

Before making such a pattern or core box, however, carefully study the drawings to determine the shape of the casting to be made.

Lecture 11

OUTBOARD-MOTOR CYLINDER

When making the pattern and core boxes for a motor block which has the cylinder and water jacket combined in a single casting, as in Figs. 351 and 352, the core work becomes the most intricate part, owing to the many details usually found in motor

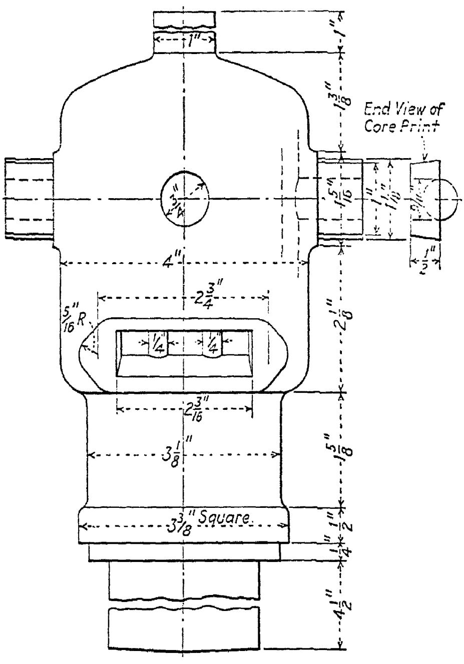


FIG. 350.

design. The pattern is made up in two parts and has the dividing line along the axis of the cylinder. Core prints are attached to provide for the support of the cores where the various openings are to appear in the casting.

The internal cylinder opening, commonly called "the bore," is cored out by the use of a balance core which is supported from the open end of the casting.

The small core print at the top of the cylinder is not sufficient to support the core to any great extent, but is useful to center and steady the core when placed in the mold. The expanded size of the top core print over the actual opening in the casting is made to give an increased bearing for the core, but should not be larger in diameter than the opening in the top of the water-jacket core, through which the top end of the cylinder core must pass when being assembled.

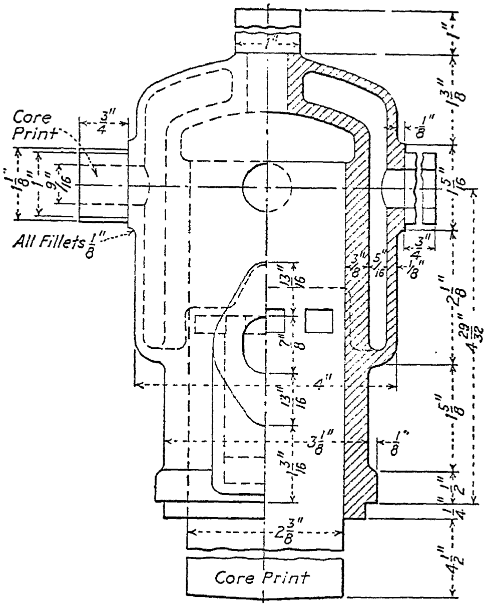


Fig. 351.

The water-jacket core is the most difficult to hold securely in place, and by means of an enlarged core print of special shape much of this difficulty is overcome (see Fig. 350).

The cores for the intake and exhaust openings are made in separate parts and, when placed in the mold, give a partial support to the internal cylindrical core at their points of contact.

The pattern is made in two parts and has the dividing line along the axis of the cylinder. It is turned on a lathe to form it into the desired shape.

The water-jacket core prints, base flange, exhaust, and carburetor surfaces are then made and attached to the main part of

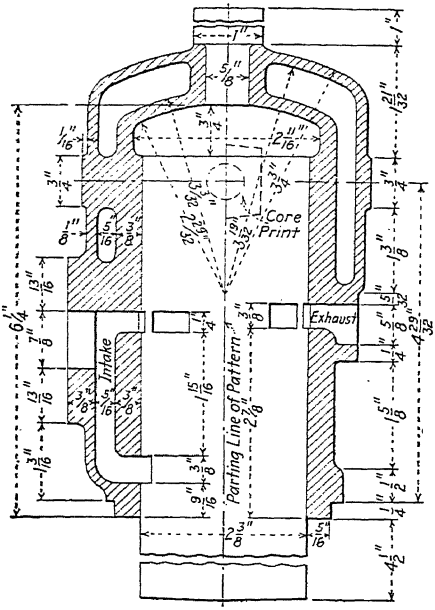


FIG. 352.

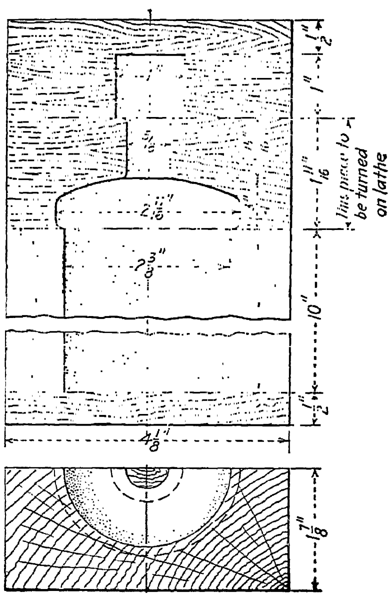


FIG. 353.

the pattern, according to their respective locations. When completed they should correspond to Fig. 350.

The core boxes, comprising an internal cylindrical core, water jacket, exhaust, and intake core boxes are next made.

The internal cylindrical core box is made from a number of different shaped parts, as shown in Fig. 353. These parts are then assembled according to their respective places and when securely fastened together become the finished core box.

The water-jacket core box is made in a similar way to that of

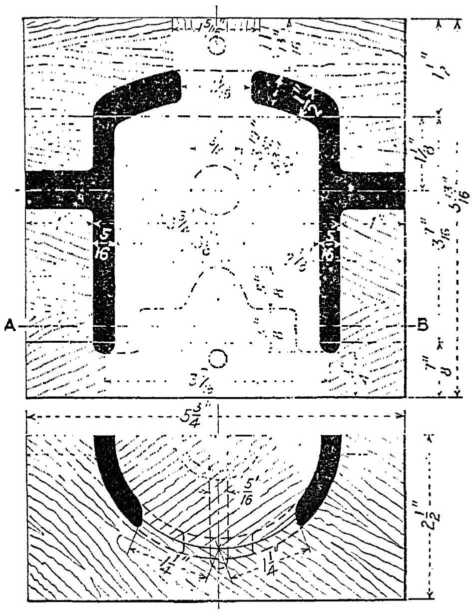


Fig. 354.

the cylindrical core box, but in addition has a loose center part which is used to form the inside surface of the core (see Figs. 354 and 355).

The core boxes for the exhaust and carburetor openings are of a smaller type, although quite difficult to make and must be made to form a perfect fitting core at the point where they come in contact with the internal cylindrical core, as well as give a proper shape and support in the mold (see Fig. 352).

In molding the pattern, a two-part flask is used. The impression of the pattern is made in the usual way, after which the

exhaust and intake cores are set and anchored in place in the mold.

The water-jacket core is then placed around the internal cylindrical core and when these two cores are simultaneously placed in the mold they are adjusted to their proper places, according to the shape and location of the core print on the pattern.

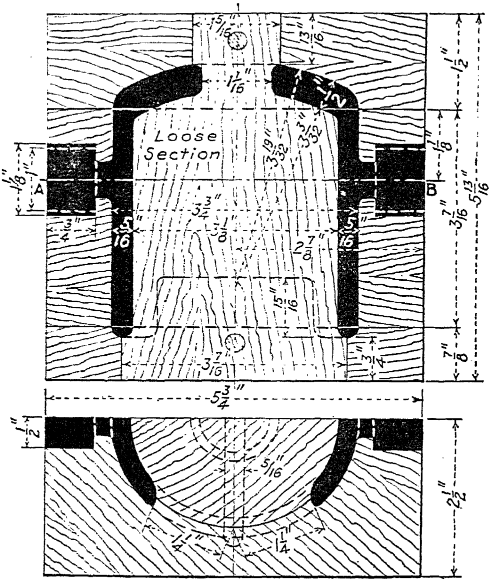


FIG. 355.

The cope, having the proper provision for pouring and venting, is then placed in position over the drag. This completes the mold and it is then ready to receive the molten metal which forms the casting.

Lecture 12

HEAVY-DUTY CYLINDER BLOCK, WITH REMOVABLE SLEEVES

For economy in manufacturing certain types of heavy-duty cylinder blocks, the method shown in Fig. 356 is considered a most satisfactory one.

It will be seen that the outside wall of the block and the crankcase are cast in one piece. Provision is made for inserting the

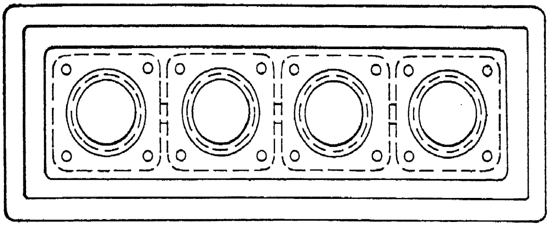


FIG. 356.

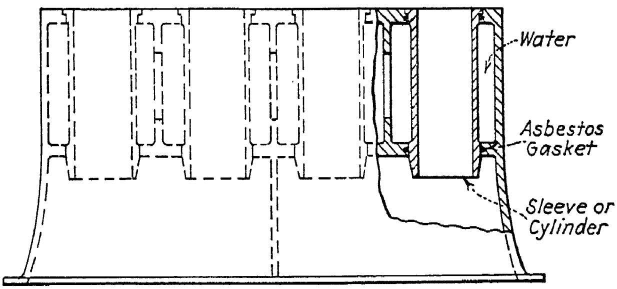


FIG. 357.

cylinder sleeves into the block, thereby forming the water-jacket space and the walls of the cylinders.

The pattern is made to represent the combined block and crankcase which is molded in a vertical position. This method greatly simplifies the molding and core work and eliminates the possibility of a spongy cylinder wall, which is sometimes produced when the water jacket and cylinder are combined in a single casting.

When the pattern has been drawn from the mold, the cores which form the shape of the inside walls of the block are first placed in the lower portion of the mold. These cores are held in position by means of the core prints which represent the cylinder openings. The crankcase cores, which are made in two sections, are then placed in position in combination with those of the cylinder block. They are held in position by means of the projecting portion of the cores on the top side of the mold, and by their interlocking into the cylinder block cores below.

The top section of the mold is next made and is used as a covering to hold the cores in place; it is provided with a pouring basin, gates, riser, and vent openings.

Much can be said in favor of this type of cylinder block, owing to the perfect alignment and elimination of oil leakage between the crankcase and the cylinders.

The cylinder walls are sleeves which are made from a finer grade of metal than that required in the main block. They are machined both inside and out; this gives a uniform thickness and eliminates "hot spots" which are so detrimental to the smooth performance of the engine.

The sleeves are pressed into the block, and by means of asbestos packing rings at the top and bottom of each cylinder sleeve, a perfect union is made which prevents any leakage of water into the crankcase or cylinders. Should a cylinder become scored or worn, it can be quickly and easily removed for replacement.

GASOLINE-ENGINE PISTONS

The pattern for the gasoline-engine piston is of the solid or one-piece type, and has an extension core print which provides for the use of a hanging core. The pattern is made to correspond to the outside dimensions of the piston, including a centering pin for locating the core print. The core print is made as a separate part and is attached concentrically with the pattern.

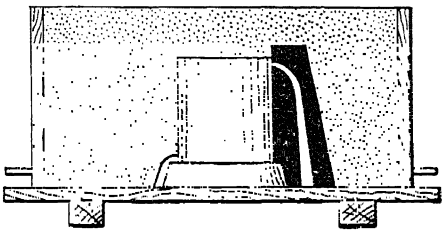


FIG. 358.

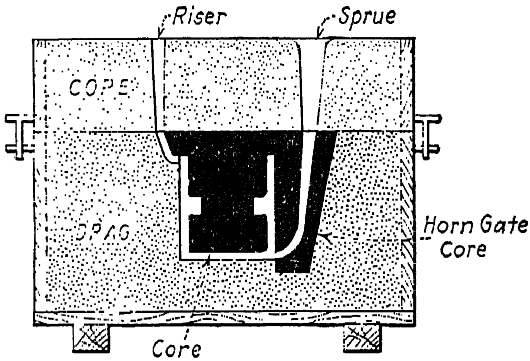


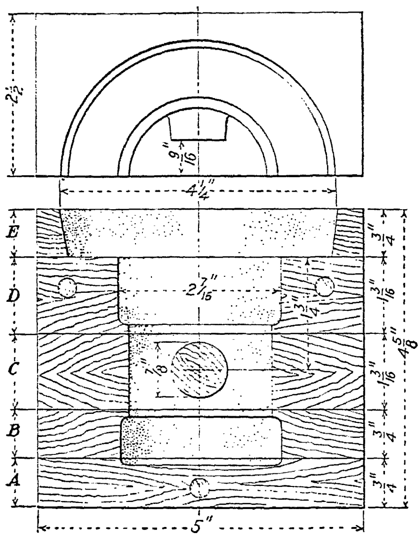
FIG. 359.

The core box for the piston is made from a number of pieces according to the design of the inside shape of the casting (see Fig. 361). These pieces are made to the required thickness and are attached to a face plate in pairs, and then turned to size. When completed the parts are assembled and fastened together, forming the desired shape of the core box. The box may be

used as a complete unit or in halves, according to the choice of making the core.

When pouring the metal, this type of casting is best made by the use of a *horn gate.* This gate is made from core sand and formed in a core box much the same as an ordinary core (see Fig. 362).

Right- and left-hand cores are made to permit the forming of the gate opening through which the metal flows into the mold, and must be baked to obtain hardness and strength before



FIGS. 360 and 361.

they are pasted together. That portion of the horn-gate core which comes directly in contact with the molten metal must be made to conform to the shape of the pattern. It is then placed tightly against the pattern before the sand is rammed into the flask (see Fig. 358). This type of pattern is molded in a vertical position so that the compression or top end of the piston is made in the bottom part of the mold. By this method a better grade of metal is obtained in the compression end of the piston. The inside of the piston is formed by the use of a hanging core which is held in place by the impression of the extension core print on the pattern (see Fig. 359).

The mold is made by first placing the top side of the pattern next to the bottom board (see Fig. 358). The horn-gate core

is then placed in position tightly against the pattern. Next the drag side of the flask is placed on the board and the sand is carefully rammed into the flask, completely covering the pattern and the *gate core* (see Fig. 358). The flask is then turned over and the bottom board removed. The cope is next placed in position over the drag, and the gate pin set directly over the horn-gate opening. The riser pin is also set and the parting

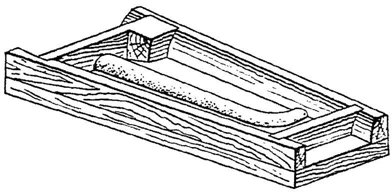


FIG. 362.

made. The cope is then filled in with sand and when carefully rammed, the gate and riser pin are removed. The cope is then vented and lifted off the drag.

Next the pattern is drawn from the mold and the hanging core set in place. The cope is again replaced on the drag and securely clamped together. The metal is then poured through the horn gate and into the mold.

Lecture 14

BRAKE-SHOE, AND OFFSET GUIDE-ARM PATTERN

ILLUSTRATING THE USE OF FOLLOW BOARDS

A follow board is a labor-saving device which is used when making a mold of a pattern which has an irregular parting line.

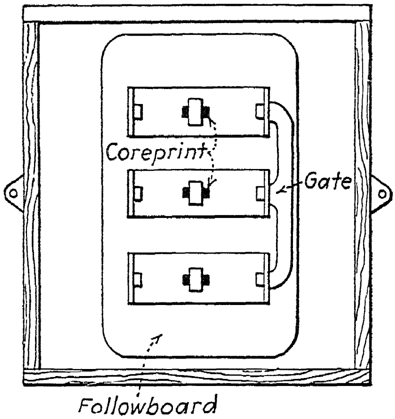


Fig. 363.

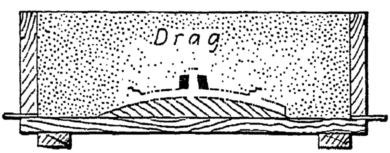


Fig. 364.

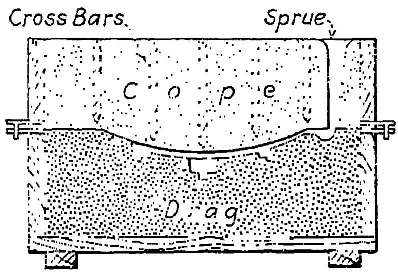


Fig. 365.

That part of the board which supports the pattern is built up to coincide with the parting line of the pattern, while the remaining surface of the follow board must lie in the same plane to receive the straight joint of the molding flask.

The brake shoe, which is shown in Figs. 363 and 364, is a good illustration of a pattern that requires the use of a follow board. Patterns for standard castings of this type should be so arranged

on a follow board that their production is possible at a minimum of cost.

The offset guide arm, illustrated in Figs. 366 and 367, is another type of pattern that requires the use of a follow board when the parting is made in the sand mold. This type is more difficult to make than the brake shoe, owing to the hanging portion of sand in the cope side of the mold.

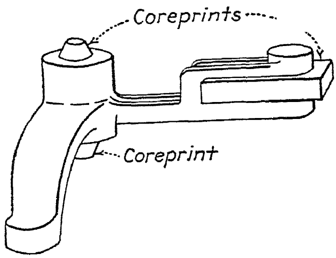


FIG. 366.

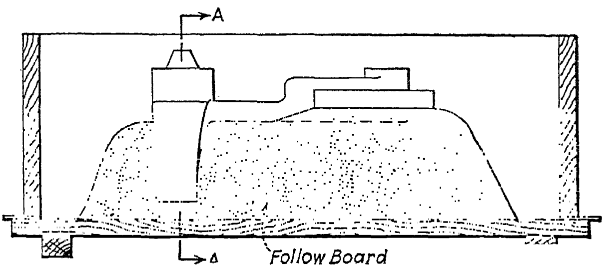


FIG. 367.

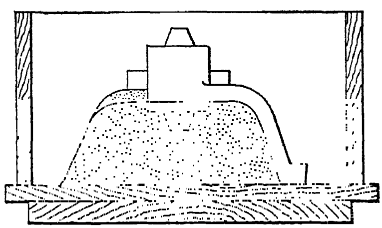


FIG. 368.

In Fig. 367 is shown the follow board and guide-arm pattern, with a portion of the pattern embedded into the follow board, leaving only the upper side of the pattern exposed for molding.

While in this position the drag side of the flask is placed on the board and the sand rammed into the flask, an impression

of the exposed portion of the pattern and the surface of the follow board being made.

The follow board and flask are then turned over and the follow board is removed from the mold, but the pattern is left embedded in the sand. The cope is then set in place on the drag and is

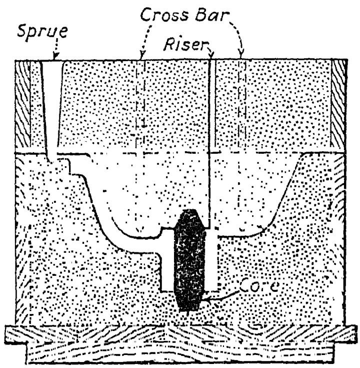


FIG. 369.

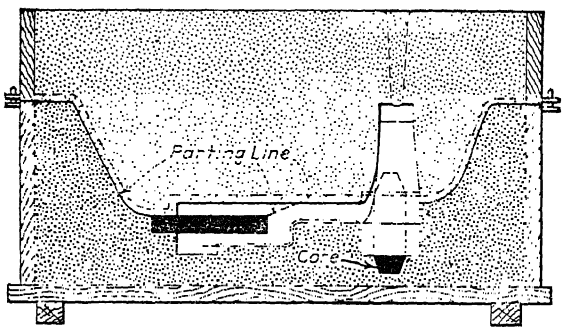


FIG. 370.

provided with cross-bars which subdivide the cope part of the flask into small compartments. This is done to increase the friction surface of the flask and to add strength to the hanging portion of the mold (see Figs. 369 and 370).

Next the parting is made and the gate pin and riser are placed in position, after which the cope is rammed. The cope is then removed and the pattern withdrawn. The mold is again assembled and, when vented and clamped together, is ready to receive the molten metal.

Lecture 15

GLOBE-VALVE PATTERNS ON DIVIDING PLATE

Globe valves and other castings of a similar type are produced in large quantities. Different methods of manufacturing are used, varying from the use of a single pattern to that of the machine-made mold.

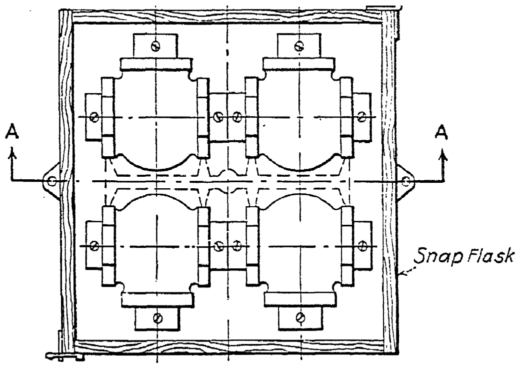


Fig. 371.

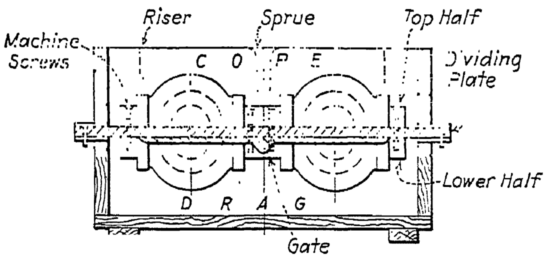


Fig. 372.

In Figs. 371 and 372, four metal patterns are shown in order to illustrate the use of a metal dividing plate. The dividing plate is made from $\frac{5}{16}$-in. aluminum plate and is cut to fit the outside measurements of the snap flask in which the mold is to be made.

When the metal patterns have been cast from aluminum, the halves are fitted together in pairs. They are then temporarily soldered together and filed or machined to a smooth surface.

Through each core print a hole about $\frac{3}{16}$ in. in diameter is drilled which is later used for holding the patterns in place on the plate. The patterns are then separated by slightly heating them where soldered, and the lower half of the pattern as it appears in Fig. 372 is then tapped out to receive a $\frac{1}{4}$-in. machine screw. The holes in the top halves are then reamed out to allow for the $\frac{1}{4}$-in. machine screw to pass through.

Next the patterns are arranged on the top side of the plate as indicated in Fig. 371. Quarter-inch holes are then drilled through the plate which permits the fastening of the two halves of these patterns together with the dividing plate between. The gate is attached to the plate by means of screws and becomes a fixture along with the patterns.

When molding, it is best to use a snap flask for light castings. Much time and the use of expensive equipment is saved by this method.

The mold is made by first assembling the patterns and snap flask together, as shown in Fig. 372. The exposed drag side is then filled with sand and tightly rammed. The flask is then turned over and the gate and riser pins are placed in position. The cope is then filled and rammed, and the gate and riser pins are removed. The cope is next removed, exposing the plate and patterns.

Then the plate and patterns are drawn out, leaving the impression of the lower half of the patterns and gate.

The cores are next set in place. When this is done, the cope is placed over the drag, and the mold is ready for pouring.

LARGE FLYWHEEL, SWEEP, AND MOLD-SECTION CORES

When casting large flywheels or driving pulleys, it is customary to make the mold by means of sweeping and the use of dry-sand sections, which are made to form the hub, arms, and rim.

The mold sections are made from core sand and formed in a core box according to the shape desired. They are then baked to

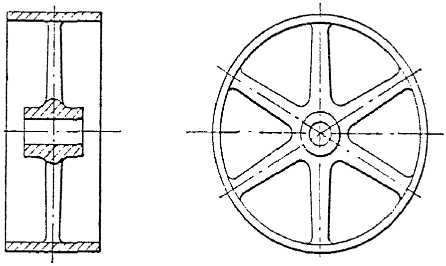


FIG. 373.

obtain hardness and strength. The sections are then placed together to form a mold into which the molten metal is poured.

Before the mold sections can be made, however, it is first necessary to make a full-sized, cross-section drawing of the pulley, as well as a top view of the hub and arm (see Fig. 373).

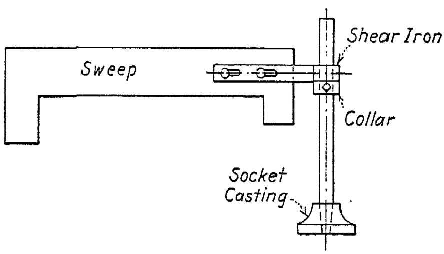


FIG. 374.

From the drawing, the shape and number of mold sections are determined, as well as the shape of the sweep which is used in forming the green-sand bed, on which the sections are placed.

To make the mold, an opening in the foundry floor is first prepared to allow for the assembly of the various sections. When

this is done, a vertical steel shaft about 2 in. in diameter is then temporarily set up in the center of the opening. The shaft has a tapered end and fits into a corresponding iron socket. The

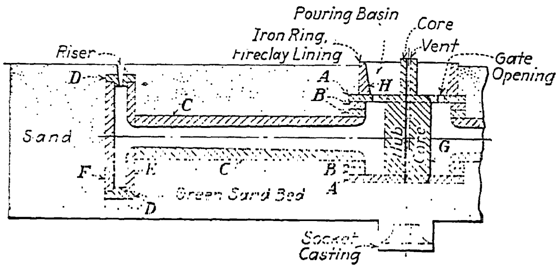


FIG. 375.

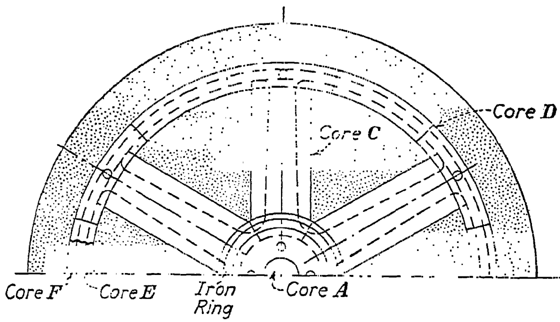


FIG. 376.

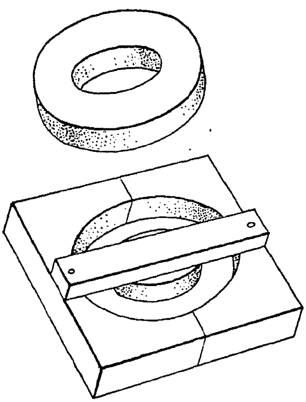


FIG. 377

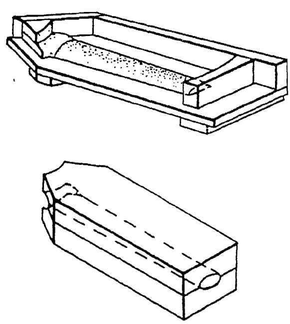


FIG. 378.

socket is embedded well into the sand and below the line of the hub (see Fig. 375). The sweep is attached to a shear iron which fits over the shaft and permits the rotation of the sweep in forming

the green-sand bed, on which the hub, arms, and rim sections are set (see Figs. 374 and 375).

When the green-sand bed has been formed, the hub ring sections *A*, *B*, and *B* are then set into place. This forms the lower part of the hub and brings the surface of *B* in line with the arm bed (see Fig. 375).

The arm sections are next set in place as illustrated in Figs. 375 and 376. They are made in two halves and fastened together with paste. This forms the complete arm section (see Figs. 378 and 379).

The base sections *D* which support the rim sections *E* and *F* are next placed in position. The shoulder on the base sections

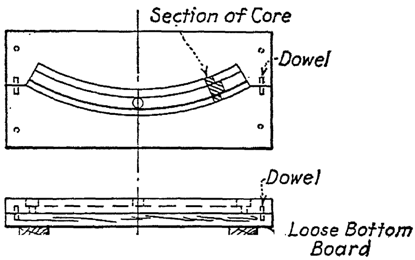


FIG. 379.

D provides a means of spacing and holding the rim sections in their proper place. The edges of the pulley rim are formed by the inside surfaces of sections *D* (see Fig. 375).

Next the inside rim sections *E* are set in place. Six of these have a center opening which corresponds to the opening in the rim end of the arm sections. Where the rim and arm sections come together the openings must coincide (see Figs. 375 and 376). The remaining space left between the arms is then filled in with the blank sections. The number used depends on the variation of the circumference of the pulley rim (see Figs. 380 and 381).

The outside rim sections *F* are next set in place. Section *D* is used to form the top edge of the rim and to hold the rim sections *E* and *F* in place.

When the rim sections are being built into place, they should be staggered. This prevents the section joints from coming directly opposite to each other which gives a stronger construction of the mold.

The top sections *D* are provided with suitable openings to permit venting and pouring (see Fig. 375).

Next the upper side of the hub is built up with sections *B* and *B*.

The vertical shaft used for centering the sweep is now : The hub core *G* is then placed in position and fits into section *A* which holds it concentric with the hub sections. Section *A* in the upper part of the hub is then set over the tapered end of the hub core *G* which completes the assembly of all sections. The top section *A* has three, $1\frac{1}{2}$-in. holes through it which provide a gate opening for pouring the metal.

The pouring basin is made by using an iron ring of suitable size, and is lined with fire clay to prevent burning of the ring. The pouring basin is set directly over the top hub section *A*.

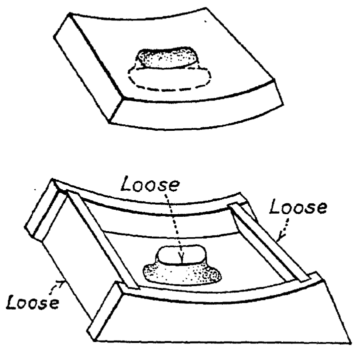


FIG. 380.

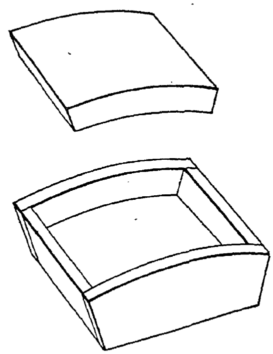


FIG. 381.

The gate openings in section *A* are temporarily closed off with pieces of tin placed over each hole. This allows for the metal when poured to accumulate into a sufficient quantity to form a static head.

The heat of the molten metal will quickly melt the tin coverings and the metal is released and flows into the mold. The supply ladle keeps the basin well filled with metal until the mold has been filled.

During the process of building the various sections into place, the joints must be carefully sealed over with graphite paste which prevents any leakage and gives a smoother surface.

Before the mold is ready for pouring, loose sand is carefully packed around the rim sections and over the arms and hub, filling the entire space up to the level of the pouring basin. On the rim is set small pouring openings which permit pouring when neces-

sary. Riser openings are also made on the rim section of the mold which provide for venting and counteract excessive shrinkage.

Before the metal is poured into the mold, the surface of sand covering the mold must be leveled off. This is done to insure a good foundation for the pressure weights which must be set on top of the mold. This keeps the mold sections from being displaced during the process of pouring the casting.

When the casting has cooled, the sand and mold sections are broken away from the casting which is then ready for cleaning and machining.

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